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Invading Martian Territory

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Now, ETX pushbutton electronic control — for only *$595* complete!

Already the largest-selling modern telescope in the world, the Meade ETX has been re-engineered for 1999 to provide the very latest in microprocessor-controlled capability.

New Fork Mount Design with Standard-Equipment Dual-Axis Drive System: The ETX-90/EC's fork mount includes high-torque DC motors on both telescope axes, permitting electronic operation from the standard-equipment plug-in hand controller.

Pushbutton Electronic Hand Controller: Use the hand controller at any of four dual-axis speeds: 8x for image centering in the main telescope at high power; 32x for image centering at lower power or for pushbutton object-tracking in the altazimuth mode; 0.75°/sec for image centering in the viewfinder or for terrestrial tracking; 5°/sec for fast slewing across the sky.

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Optional Autostar™ Capability: Plug in the optional Meade Autostar computer controller *(see facing page)* for LX200-type operation, including automatic GO TO capability to more than 12,000 celestial objects.

Plus the features that created the ETX revolution:

Maksutov-Cassegrain Optical System: Manufactured at the Meade Irvine, California facility, ETX diffraction-limited optics produce images so high in contrast, brightness, and resolution that the ETX consistently outperforms telescopes of larger apertures.

Flip-Mirror System: Flip the internal optical flat mirror "up" for 90° observing; flip the mirror "down" for terrestrial observing with the optional #932 45° Erecting Prism or for photography with the optional #64 Photo Adapter.

SPECIFICATIONS: ETX-90/EC Astro Telescope — Includes Maksutov-Cassegrain optical tube assembly (D = 90mm, F = 1250mm, f/13.8) with EMC super multi-coatings; internal flip-mirror system for either straight-through or 90° observing position; fork mount with electric slow-motion controls, setting circles and locks on both axes; electronic control panel; 4-speed (8x, 32x, 0.75°/sec, 5°/sec) dual-axis motor drive system with hand controller; sidereal-rate tracking in equatorial mode with optional table tripod or deluxe field tripod; internal battery compartment accepting eight (user-supplied) AA-size batteries; 8 x 21mm erect-image viewfinder; Series 4000 Super Plössl 26mm eyepiece (1.25"); operating instructions. Net weight 9 lbs. — **$595** (+ $20 P & S).

MEADE
ETX-90/EC
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COMPUTER CONTROL
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HBX
ON
OFF
AUX
12v
IN
FOCUS
OUT
SPEED
MODE
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Meade ETX-90/EC: complete as shown, with electronic hand controller. . **$595**
(+ $20 packing & shipping in the 48 states)

OPTIONAL SYSTEMS FOR ETX-90/EC

#497 Autostar Computer Controller	$149.00
#880 Equatorial Table Tripod	29.95
#883 Deluxe Full-Length Field Tripod	199.95
#825 8 x 25mm Right-Angle Viewfinder	49.95
#774 Hard Carry Case	99.95
#932 45° Erecting Prism	49.95
#64 Photo Adapter	34.95
#1244 Electric Focuser, plugs into control panel	119.95

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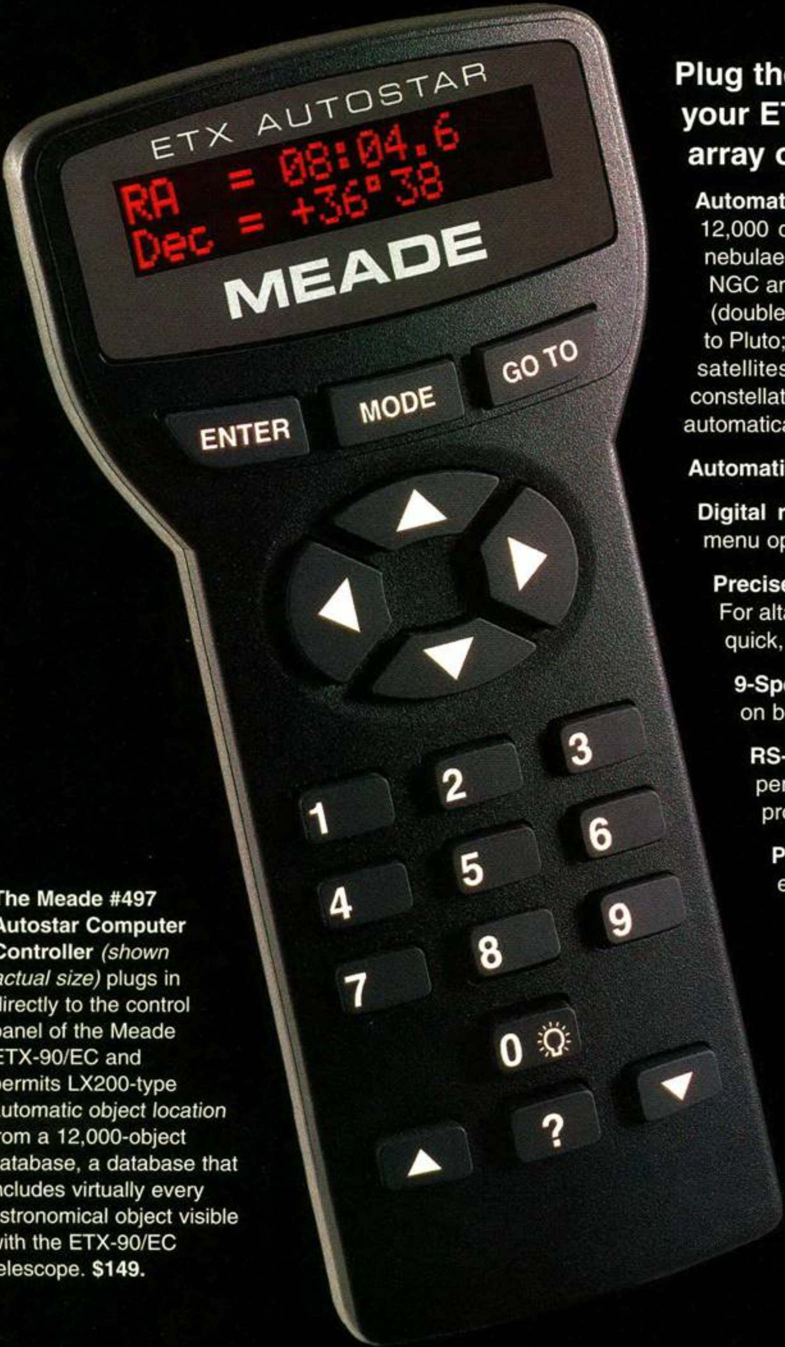
Add the Meade Autostar™ hand controller to your ETX-90/EC for fully automatic GO TO object location ...only *$149!*



The Meade #497 Autostar Computer Controller *(shown actual size)* plugs in directly to the control panel of the Meade ETX-90/EC and permits LX200-type automatic object location from a 12,000-object database, a database that includes virtually every astronomical object visible with the ETX-90/EC telescope. **$149.**

Plug the #497 Autostar Computer Controller into your ETX-90/EC and you're ready for an incredible array of LX200-type capabilities:

Automatic dual-axis GO TO function at 5°/sec to any of more than 12,000 database objects, including deep-space objects (galaxies, diffuse nebulae, planetary nebulae, star clusters — the best objects from the IC, NGC and Caldwell catalogs, as well as all 110 Messier objects); 900 stars (double stars, variable stars, SAO stars); the 8 major planets from Mercury to Pluto; 26 of the brightest asteroids; 15 periodic comets; 50 earth-orbiting satellites; plus user-defined objects and the centroids of all 88 constellations. Select any of these objects, press ***GO TO*** and the telescope automatically slews to the object, placing it in the telescopic field.

Automatic GO TO function to *any* object of known R.A. and Dec.

Digital readouts of telescope position (continuously in R.A. and Dec.), menu options, glossary, and utility functions.

Precise sidereal-rate tracking in either altazimuth or equatorial modes. For altazimuth tracking, set the telescope on its drive base and perform a quick, easy alignment.

9-Speed Dual-Axis Operation: Pushbutton operation of the telescope on both axes, simultaneously, at any speed from 2x sidereal to 5°/sec.

RS-232 Serial Port: For operation of the telescope through a personal computer, using Meade Epoch 2000 sky software or programs of the user's own writing.

Plus: over 20 other menu options, including guided tours, major event menus, user-defined terrestrial objects, and much more.

MEADE
COMPUTER CONTROL

(right) **Meade ETX-90/EC,** shown with optional #497 Autostar Computer Controller plugged into the telescope's control panel.

Write, call, or fax Meade Instruments for your free copy of the 100-page Meade General Catalog.

Prices shown are suggested U.S. mail-order retail prices.
Patents pending on ETX-90/EC and Autostar.

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Astronomy®

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From *The Glorious Constellations*, © 1991; Harry N. Abrams, Inc.

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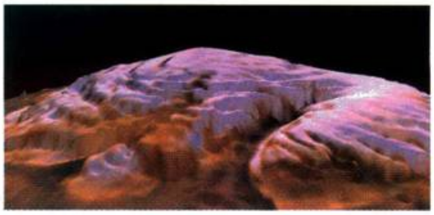
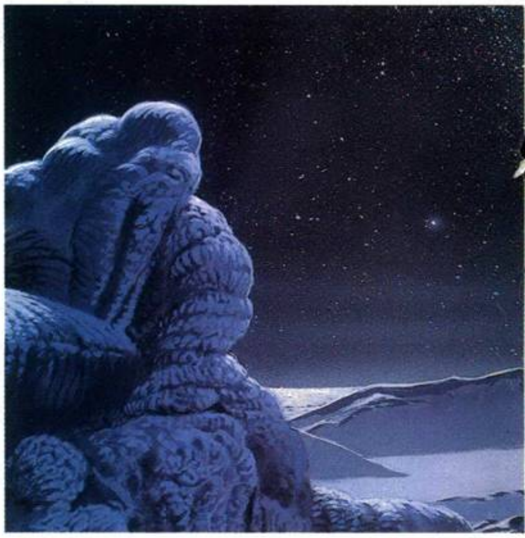
MOLA Team/NASA/Greg Shirah (SVS)





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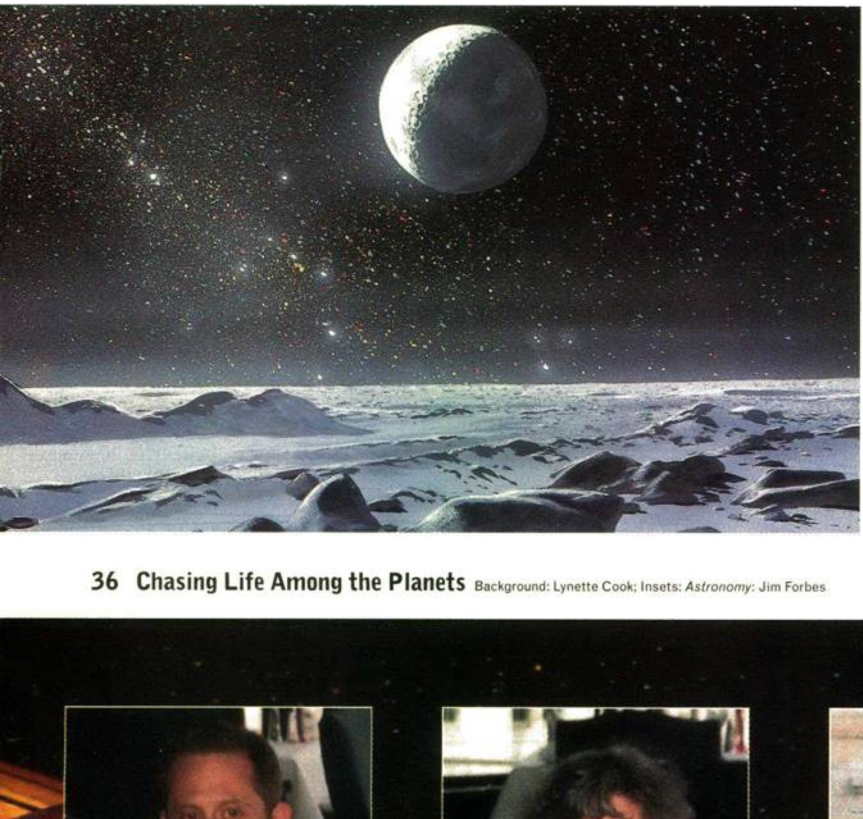

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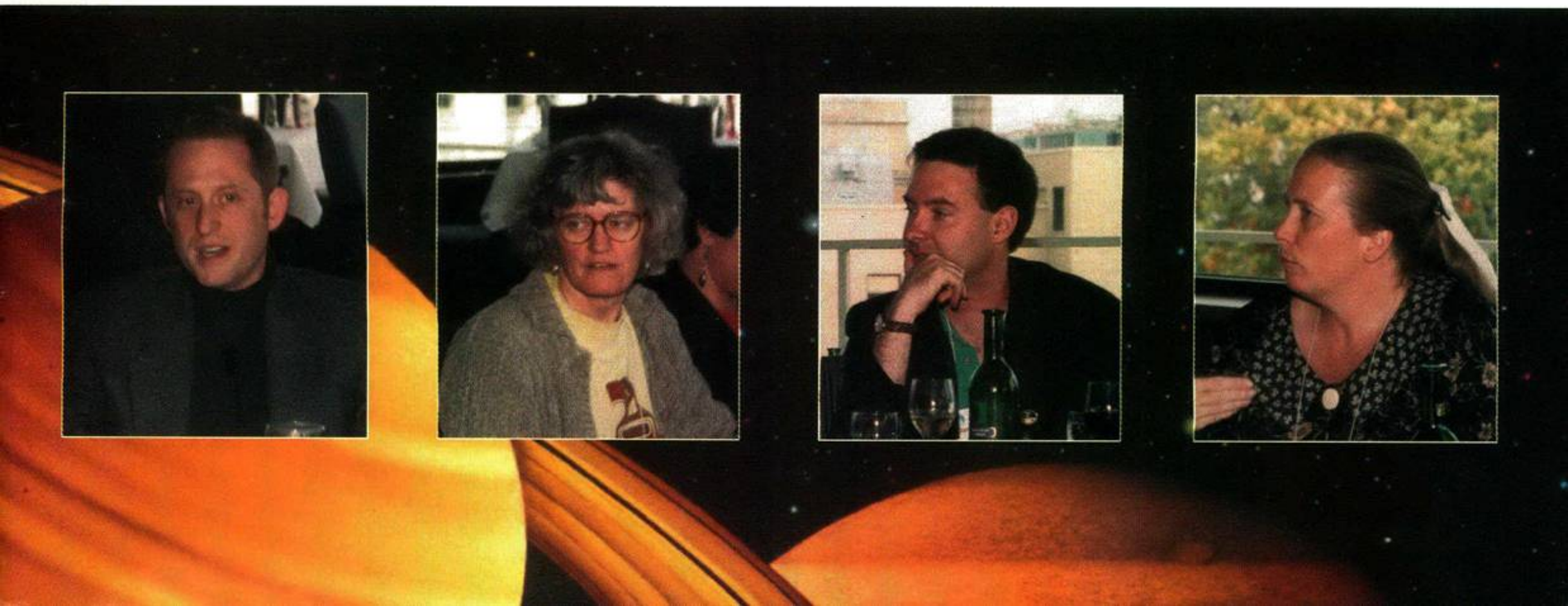


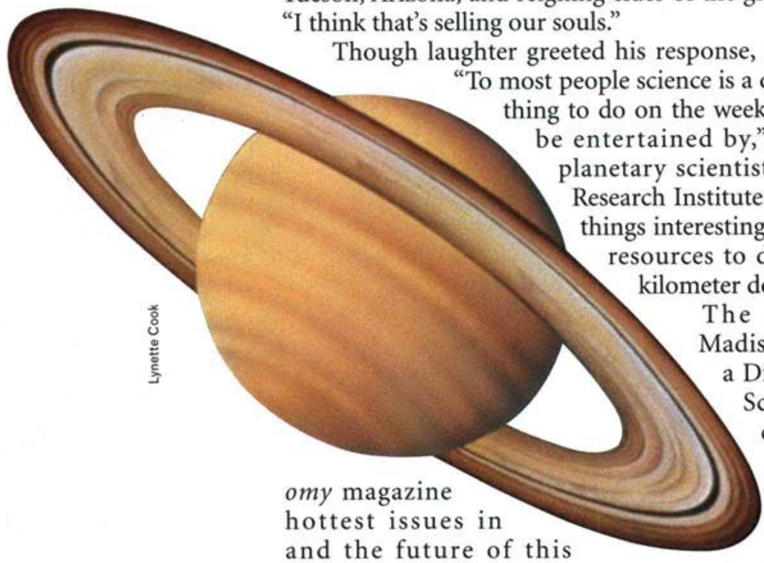
BEHIND THE SCENES

BY BONNIE BILYEU GORDON

Astronomy as Entertainment

At a recent gathering of planetary scientists, a startling argument erupted over the importance of making science entertaining. "I think we have to start recognizing that it's possible to combine entertainment and science," said Carl Pilcher, NASA's deputy administrator for space science.

William Hartmann of the Planetary Science Institute in Tucson, Arizona, and reigning elder of the group, snapped back, "I think that's selling our souls."


Lynette Cook

Though laughter greeted his response, the debate was on. "To most people science is a diversion; it's something to do on the weekends, something to be entertained by," said Alan Stern, planetary scientist at the Southwest Research Institute. "We need to make things interesting so we can have the resources to do things like go a kilometer down into Mars."

The scientists — in Madison, Wisconsin, for a Division of Planetary Sciences meeting — came to lunch with editors of *Astronomy* magazine to discuss the hottest issues in planetary science and the future of this infant specialty. The argument over the importance of making their science entertaining was not resolved in the hours they spent with us. A similar argument has surfaced and resurfaced among the editors of *Astronomy* for several years.

When we were asked by the publisher to describe precisely and concisely what it is we do here, we ended up with a mission statement that says: We hope to give our readers more than they expect by producing astronomy publications that engage, inform, inspire, and entertain. But there was a good deal of discussion over the word "entertain."

It's our job to translate complex subjects for a popular, interested, educated audience. We try to entice readers to have a little fun as they grow. If they wanted to read a journal, there are several good ones they could buy.

To find out much more about the business of planetary science, join us on page 38 for some rousing conversation among heavyweights in the field. They were particularly interested in talking about the search for life in the solar system. . . .

Astronomy

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Choose either the Meade 203SC/300, with the exact same optical tube assembly as more expensive Meade 8" Schmidt-Cassegrains, or the Model 102ACHR/300 with its exquisite 4" Meade air-spaced achromatic lens. Both telescopes are equipped with the high-performance Meade LXD 300 equatorial mount with dual-axis aluminum worm gears.

SPECIFICATIONS: Models 203SC/300 and 102ACHR/300 — Each telescope includes 8" f/10 Schmidt-Cassegrain *or* 4" f/9 Achromatic Refractor optical tube assembly with EMC super multi-coatings; LXD 300 equatorial mount with aluminum worm gears, micrometric manual slow-motion controls, and setting circles on both axes; manual control for azimuth alignment; elevation control and scale for polar alignment at latitudes from 15° to 50°; adjustable full-length aluminum tripod with bubble level and accessory shelf; 6 x 30mm achromatic viewfinder; eyepiece-holder (1.25"); #918A diagonal prism (1.25"); Series 4000 Super Plössl 26mm eyepiece (203SC) *or* Series 3000 Plössl 25mm eyepiece (102ACHR); provision for addition of optional #812 Polar Alignment Finder; operating instructions. **8" — $795** (+ $65 P & S); **4" — $595** (+ $55 P & S); **#535 R.A. Motor Drive System...$99; #812 Polar Alignment Finder...$49.**

LXD 500 **For even broader capability, use the Meade® high-precision LXD 500 equatorial mounting, 20% larger and with dual-axis bronze worm gears — the finest equatorial mounting available in its price class.**

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MEADE LX50

Advanced technology at the most affordable prices *ever.*

- **Battery-Powered, Completely Cordless Operation!** Meade LX50 models operate for more than 50 hours from six AA-size batteries inserted through the telescope's control panel.

- **Standard-Equipment Declination Motor and Hand Controller:** Plug the hand controller into the LX50 control panel and you're ready for dual-axis drive capability at any of 4 photo-guide or microslew speeds: 2x, 8x, 16x, or 32x, plus quartz-controlled sidereal-rate tracking in R.A.

- **Multi-Function Control Panel:** Includes connectors for CCD autoguiders; for the standard-equipment Declination motor; and for the optional Magellan II Computer-Corrector *(below).*

- **Super Multi-Coated Optics:** The exact same EMC super multi-coated optical tube assemblies included with Meade LX200 models.

- **Massive LX200-type Fork Mounts:** Manufactured of the same aluminum castings as Meade LX200 models. Massive, rigid mounts that include the Meade LX worm-gear drive system with low periodic error for advanced photographic or CCD imaging applications.

SPECIFICATIONS: 7", 8", and 10" LX50's — Each complete telescope includes 8" or 10" f/10 Schmidt-Cassegrain or 7" f/15 Maksutov-Cassegrain optical tube assembly with EMC super multi-coatings; heavy-duty LX200-type fork mount; 5.75" LX worm gear system in R.A.; multi-function control panel; DC servo Declination motor; manual and electric slow-motion controls on both axes; setting circles on both axes; keypad hand controller; 4-speed drive controls on both axes; battery compartment accepting six (user-supplied) AA-size batteries; 25 ft. power cord for telescope operation from 12v. auto cigarette lighter plug; 6 x 30mm (7" and 8" models) or 8 x 50mm (10") viewfinder; 1.25" diagonal prism; Series 4000 Super Plössl 26mm multi-coated eyepiece (1.25"); standard equatorial wedge with elevation scale, bubble level, and azimuth control; complete operating instructions.

8" LX50 Schmidt-Cassegrain	**$1395.**
10" LX50 Schmidt-Cassegrain	**1695.**
7" LX50 Maksutov-Cassegrain	**1795.**
Variable-Height Field Tripod	**295.**

Packing and shipping in the 48 states: 8"—$105; 10"—$145; 7"—$125; 7" Tube Assembly—$65.

Meade Magellan™ II Computer-Corrector for LX50 Telescopes: Plug the Magellan II into the control panel of your LX50 and enjoy an incredible range of advanced capabilities. ■ Fast manual slewing to any object, either from input RA and Dec or from the 12,218-object database. ■ High-resolution 4096-pulse encoders (5.3 arc-minute precision), concealed in special LX50 encoder compartments. ■ Large 32-character, red-backlighted display. ■ Quick 2-star alignment. ■ Four-speed (2x, 8x, 16x, 32x sidereal) dual-axis drive corrector/microslewing system.

#2024: Magellan II for LX50's—Includes Magellan II hand controller *(shown above)*; encoders for both axes; all required mounting hardware. Installs to any LX50 in minutes. **$495.** + $15 packing and shipping in the 48 states.

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Meade 8" LX50 Schmidt-Cassegrain Telescope *(shown with optional Field Tripod)*

MEADE LX200

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MEADE LX200
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Meade 10" LX200 Schmidt-Cassegrain Telescope

Prices shown are suggested U.S. national mail-order retail prices.

The largest-selling serious telescopes in the world.

In virtually every country in the world where serious telescopes are sold, more Meade LX200's are sold than all competing models combined. *Standard-equipment includes:*

- **Superb Optics:** LX200 diffraction-limited imaging capabilities are a legend in the industry; optical performance approaches that of a fine *ED* apochromatic lens.
- **Automatic GO TO Capability:** Meade LX200's are *the only commercial telescopes ever manufactured* that automatically GO TO any input R.A. and Dec., or to any of 64,359 objects in the onboard database, *to a precision of one arc-minute or better.*
- **LX200 High-Precision Pointing™** is so precise it permits the positioning of *every* selected object on *every* commercially-available CCD chip *every* time, automatically — *a feat no other telescope priced under $40,000 can accomplish.*
- **Permanently-Programmable Smart Drive™** routinely achieves 5 arc. sec. periodic error, an observatory standard.
- **9-Speed Dual-Axis Electronics:** Electronics that cover every possible contingency of telescope positioning—from 2x photo-guide, to 32x image centering, to 8°/sec. slewing across the sky, as well as 6 other dual-axis drive speeds in between.
- **Field Operation:** No other telescopes of such incredible capabilities transport so readily for field operation. The compact, optional #1812 Electronic DC Adapter allows for field powering directly from an automobile cigarette lighter plug.

SPECIFICATIONS: 7", 8", 10", and 12" LX200's — Each complete telescope includes 8" or 10" (f/6.3 or f/10) or 12" f/10 Schmidt-Cassegrain or 7" f/15 Maksutov-Cassegrain optical tube assembly with EMC super multi-coatings; heavy-duty fork mount with 4" polar ball bearing, dual-axis 5.75" worm gears, and multi-function control panel; manual and electric slow-motion controls on both axes; keypad hand controller with digital readout display, permanently programmable Smart Drive, 9-speed drive controls on both axes (7-speed on 12"), High-Precision Pointing, and GO TO controller; 64,359-object onboard celestial software library; 25 ft. power cord and adapter for telescope operation from 115v.AC; 8 x 50mm viewfinder; 1.25" diagonal prism (7", 8", 10") or 2" diagonal mirror with 1.25" adapter (12"); Series 4000 Super Plössl 26mm eyepiece; standard field tripod (7", 8", 10") or giant field tripod (12"); operating instructions.

8" LX200 Schmidt-Cassegrain	**$2795.**
10" LX200 Schmidt-Cassegrain	**3195.**
12" LX200 Schmidt-Cassegrain	**4495.**
7" LX200 Maksutov-Cassegrain	**3295.**

Packing and shipping in the 48 states: 8"—$105; 10"—$145; 12"—$215; 7"—$125.

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MEADE STARFINDER DOBSONIANS

Now with Series 4000 Super Plössl 26mm eyepiece as *standard equipment!* Consider these features:

Series 4000 SP26mm Eyepiece (1.25"): The premium SP26mm ocular permits all Meade Starfinder Dobsonians to perform absolutely to their maximum capabilities. This $80 eyepiece is now **standard-equipment** on all Meade Dobsonians.

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Rigid, Durable, Beautiful Dobsonian Mountings, manufactured of cabinet-quality materials, provide extremely smooth motions of the telescope in both altitude and azimuth. Both telescope axes ride on zero-backlash Teflon/Nylon bearings, facilitating the quick location and easy tracking of celestial objects.

Full-Size 1.25" Rack-and-Pinion Focuser: For smooth, precise focusing of the image without wobble or backlash. Focus travel is 2.6"; accepts 1.25" eyepieces.

4-Vane Steel Secondary Mirror System: Permits locked-in support and precise centration and alignment of the secondary mirror.

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Optical Tubes: The same strong, spiral-wound Sonotubes™ used on Starfinder Equatorials *(right),* tubes with excellent insulating characteristics that reduce internal thermal currents to an absolute minimum.

Performance! *Meade Starfinder Dobsonians and Equatorials are the largest-selling Newtonian reflectors of their apertures in the world.* Every Starfinder model opens up the skies to an extremely wide range of serious visual observing; all 110 Messier objects, thousands of NGC objects — nebulae, galaxies, star clusters, in all their variations of form, color, and extent, as well as the Moon and planets in stunning high-resolution detail. Starfinder Dobsonians are telescopes for visual observing; motor-driven Starfinder Equatorials may be used, in addition, for lunar and planetary photography, and even for limited deep-space photography.

Packing & UPS Shipping Charges to any address in the 48 states: 6"—$39; 8"—$49; 10"—$69; 12.5"—$79; 16"—$45 packing, shipped truck freight collect.

$270 Dobsonian Deluxe Accessory Package...only $49.95!

Outfit your Meade Dobsonian with all of the most popular accessories for advanced observing. At the time you order any Dobsonian model, specify the following Deluxe Accessory Package for your telescope, in place of the standard-equipment focuser, viewfinder, and eyepiece, ***for a total of only $49.95 additional:***

- **1 - Meade #77 2" Giant Rack-and-Pinion Focuser,** with machined aluminum eyepiece-holders for both 2" and 1.25" eyepieces; includes drawtube lock and 2.6" focuser travel. *(reg. $59.95)*
- **1 - Meade #637 6 x 30mm Achromatic Viewfinder,** with wide 7° field; 2-ring metal bracket. *(reg. $49.95)*
- **2 - Meade Series 4000 Super Plössl 9.7mm and 26mm** multi-coated eyepieces — premium-grade eyepieces for high-resolution lunar, planetary, and deep-space observing. *(reg. $79.95 each)*

Purchased separately, the Deluxe Accessory Package sells for $269.80!

Meade Magellan I Telescope Computer System

Attach the optional Magellan I Telescope Computer System to your Starfinder Dobsonian and finding any of 12,218 celestial objects, or *any* object of known R.A. and Dec., is almost as easy as pointing the telescope! Magellan I's database includes the following objects:

7,840	NGC objects; the complete NGC catalog
4,093	IC objects from the Index Catalog
125	user-defined objects
110	Messier objects; the complete catalog
42	alignment stars for the Magellan system
8	major planets, from Mercury to Pluto
12,218	objects, total

MEADE
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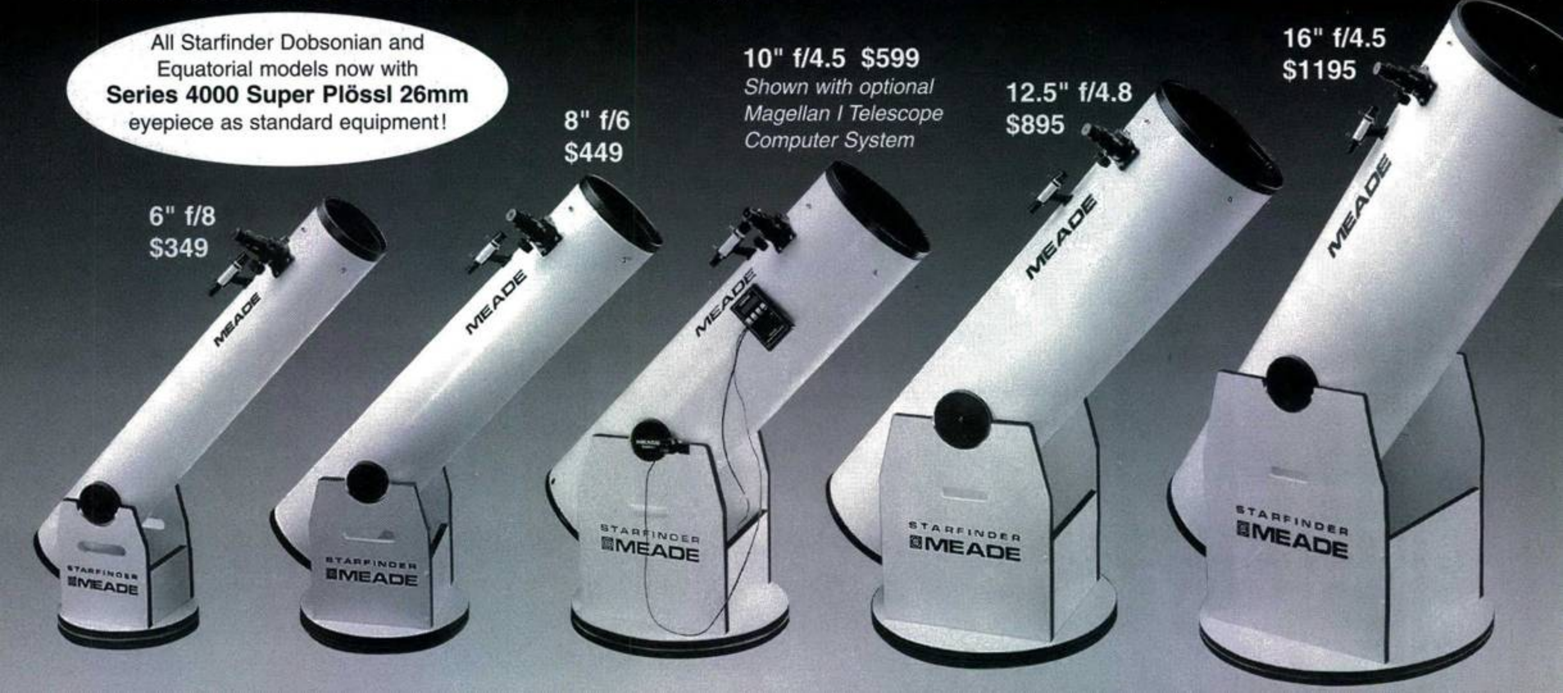
ON
MAGELLAN I
TELESCOPE COMPUTER SYSTEM

Magellan I is supplied *complete* with control/display unit (4" x 5" x 1.25"); premium-grade, high-resolution encoders for each telescope axis (encoder precision is 5.3 arc minutes); RS-232 serial interface; bracket for placement of the controller on the telescope tube; and attachment hardware. Just add the user-supplied 9v. transistor radio battery, and Magellan I is ready to use. First-time installation is quick and simple.

#2010: for Meade Starfinder Dobsonian
6", 8", 10", 12.5", or 16" . . . . $295.
Packing & shipping in the 48 states—$15.

STARFINDER DOBSONIAN TELESCOPES ***Shown with standard-equipment 5 x 24mm viewfinder and 1.25" rack-and-pinion focuser.***



All Starfinder Dobsonian and Equatorial models now with **Series 4000 Super Plössl 26mm** eyepiece as standard equipment!

6" f/8 $349

8" f/6 $449

10" f/4.5 $599
Shown with optional Magellan I Telescope Computer System

12.5" f/4.8 $895

16" f/4.5 $1195

MEADE
STARFINDER EQUATORIALS

Special Eyepiece Offer! At the time you order any Meade Starfinder Equatorial telescope, you can buy a Meade Series 4000 Super Plössl 9.7mm eyepiece ***for only $29.95!*** *Purchased separately, the SP9.7mm eyepiece sells for $79.95.*

The fullest exposition of Meade astronomical telescopes, CCD imagers, and telescope accessories is contained in the 100-page Meade General Catalog.

Write, call, or fax Meade Instruments for your free copy!

With DC-powered drive systems for automatic tracking and Series 4000 Super Plössl 26mm eyepiece.

Professional-Grade Optical System: Hand-figured, parabolic primary mirror and elliptical flat secondary, both of Grade-A Pyrex glass. Optics are multi-coated and meet the theoretical limits of resolution.

Accessories and Components: Premium-grade multi-coated SP26mm eyepiece (1.25"); #637 6 x 30mm viewfinder with wide 7° field; strong, durable, spiral-wound optical tube with attractive white finish.

Precision Equatorial Mount: Manufactured of machined aluminum to tolerances of .001" or better, with 4"-dia. pier and die-cast tripod legs for rock-solid support of the optical tube. Moves effortlessly from object to object on precision bearing surfaces. Polar and Dec. shafts are 1" solid steel. Setting circles on both axes.

Battery-Powered Cordless Drive System! For fully automatic tracking of celestial objects. Operates over 50 hours from 6 (user-supplied) AA-batteries. Control panel also permits powering the telescope from 12v. auto cigarette lighter plug, using optional 25 ft. cord.

2" Giant Focuser: Meade #77 2" giant rack-and-pinion focuser is included as standard equipment, with eyepiece-holders for both 2" and 1.25" eyepieces.

Starfinder Equatorial 16: Includes equatorial mounting with 1.5" steel shafts, Sealmaster ball bearings, 6" dia. pier, and 6 x AA-size battery-powered worm gear drive; 8 x 50mm viewfinder; #77 2" giant focuser.

Packing & UPS Shipping Charges to any address in the 48 states: 6"—$65; 8"—$75; 10"—$90; 16"—$55 packing, shipped truck freight collect.

Meade Magellan Telescope Computer Systems

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TELESCOPE COMPUTER SYSTEM

Magellan I: Use the Magellan I computer to manually slew the telescope quickly to any of 12,218 database objects, or to any object of known R.A. and Dec. Specifications and object database are identical to Magellan I for Starfinder Dobsonians *(see facing page).*

#2011: for Meade (DC-powered) Starfinder Equatorial 6", 8", or 10" . . . . $295.
#2012: for Meade (DC-powered) Starfinder Equatorial 16" . . . . 295.

MEADE
MAGELLAN II
COMPUTER · CORRECTOR
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Magellan II Computer-Corrector: Plug the Magellan II into the control panel of your Meade Starfinder Equatorial and you have all the capabilities of the Magellan I, above, including 12,218-object database, *plus* a 4-speed (2x, 8x, 16x, 32x), dual-axis, drive corrector/microslewing system.

#2018: for (DC-powered) Starfinder Equatorial 6", 8", 10" . . 495.
#2019: for (DC-powered) Starfinder Equatorial 16" . . . . 595.

Packing & shipping in the 48 states: Magellan I–$15, Magellan II–$20.

To Order: Contact your authorized Meade Advanced Products Mail-Order Dealer, below. Prices shown are suggested U.S.A. mail-order retail prices.

ASTRONOMICS, Norman, OK.
Orders: 800-422-7876; Info.: 405-364-0858.

FOCUS CAMERA, Brooklyn, NY.
Orders: 800-221-0828; Info.: 718-436-6262.

LUMICON, Livermore, CA.
Orders: 800-767-9576; Info.: 510-447-9570.

OCEANSIDE PHOTO & TELESCOPE, Oceanside, CA.
Orders & Information: 800-483-6287.

POCONO MOUNTAIN OPTICS, Moscow, PA.
Orders: 800-569-4323; Info.: 717-842-1500.

RIVERS CAMERA, Dover, NH.
Orders: 800-245-7963; Info.: 603-742-4888.

SHUTAN CAMERA & VIDEO, Chicago, IL.
Orders & Info.: 800-621-2248; IL: 312-332-2000.

Canada:

EFSTONSCIENCE, Toronto, Ontario.
Orders & Information: 416-787-4581.

KHAN SCOPE CENTRE, Toronto, Ontario.
Orders & Information: 416-783-4140.

ADVANCED PRODUCTS DIVISION
Meade Instruments Corporation
World's Leading Manufacturer of Astronomical Telescopes for the Serious Amateur
6001 Oak Canyon, Irvine, California 92620 ☐ (949) 451-1450
FAX: (949) 451-1460 ☐ *www.meade.com*

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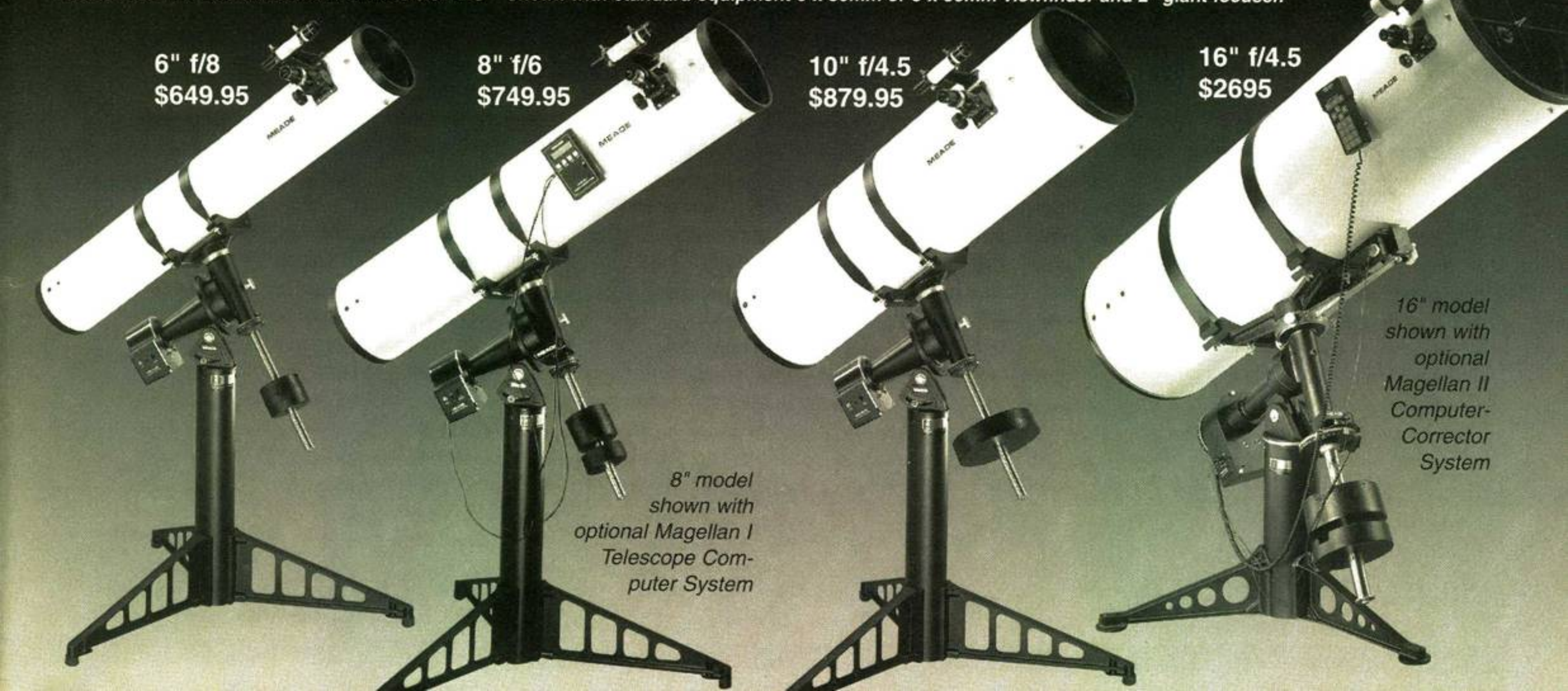
STARFINDER EQUATORIAL TELESCOPES ***Shown with standard-equipment 6 x 30mm or 8 x 50mm viewfinder and 2" giant focuser.***



8" model shown with optional Magellan I Telescope Computer System

16" model shown with optional Magellan II Computer-Corrector System

MEADE RESEARCH-GRADE ACCESSORIES

Series 4000™ Super Plössls 52° field; multi-coated

Meade 4-element Super Plössls, updated and redesigned to utilize the latest in optical glass-types, are the finest general-purpose eyepieces available. For observing hairline lunar and planetary detail, splitting close doubles, or for deep-space; guaranteed to deliver more contrast and image sharpness than any other brand. Rubber eyeguards fold down for eyeglass wearers–a feature not available on competing brands. Multi-coated. All focal lengths through 32mm are parfocal.

Super Plössls (SP; 4-elements; 1.25"; 52°):

6.4, 9.7, 12.4, 15, 20, 26mm	each:	**$79.95** (4.54)
32mm (52°); **40mm** (44°)	each:	**99.95** (5.26)
56mm (52°; 2")		**199.95** (7.02)

Series 4000™ Ultra Wide Angle 84° field; multi-coated

The ultimate eyepieces; extreme image sharpness over an amazing 84° field. A perfect optical match with Schmidt-Cassegrains and fast Newtonians.

Ultra Wide Angle (UWA; 8-elements; 1.25"; 84°)– **4.7mm: $169.95** (5.26); **6.7mm: 199.95** (5.26); **8.8mm** (1.25"/2"): **239.95** (7.02); **14mm** (1.25"/2"): **299.95** (7.02)

Series 4000™ f/6.3 Focal Reducer/ Field Flattener

Manufactured to exclusive Meade optical designs; threads on to any Meade or Celestron Schmidt-Cassegrain rear cell and converts f/10 scopes to f/6.3 (or f/6.3 SCT's to f/4), while significantly flattening the field. Use with SCT visual or photo accessories. Actual visual field is increased by 56%, for fine wide-field views of star fields and nebulae. In astrophotography, reduces exposure times by about 50%, while producing an actual field diameter of 1.5" at the film plane. A tremendous aid with CCD imagers in reducing image size for locating and centering images on CCD chips. 4-element optics; multi-coated; 41mm clear aperture. **$129.95** (5.26)

2x Telenegative Barlow (1.25")

#122: Doubles eyepiece power with sharp, high-resolution, high-contrast imaging on telescopes of all types. 27mm dia. (26mm clear aperture). Excellent corrections for chromatic and spherical aberrations at all photo-visual wavelengths. Multi-coated. 1.25" **$47.95** (4.54)

2x Short-Focus Barlow (1.25")

#126: Only 2.5" long, the #126 works well with any telescope accepting 1.25" eyepieces, even those with limited focus range. Maintains the high image quality of the #122, above. Insert the #126 into star diagonal for 2x or insert star diagonal into #126 for 3x. 26mm clear aperture. Multi-coated. **$47.95** (4.54)

2x-3x Variable Barlow (1.25")

#127: Precision internal sliding lens assembly permits continuously variable power settings between 2x and 3x. Engraved scale indicates power in use. Yields bright, sharp, high-contrast images on telescopes of all types. Multi-coated; 1.25".

$59.95 (4.54)

2" Diagonal Mirror

#929: Permits use of wide-field 2" oculars. Threads on to rear cell of Meade and Celestron SCT's. Includes multi-coated precision optical flat made at the Meade factory; with 1.25" eyepiece adapter. **#930:** Same as #929 but with 2" barrel to fit into focusers with 2" eyepiece-holders.

#929 or **#930**, each: **$99.95** (6.85)

45° Erecting Prisms

Fully coated roof prisms to invert the astronomical image in Schmidt-Cassegrains or refractors during terrestrial observations, while presenting a convenient 45° observing angle. Specify **#927** (.965"), **#928** (1.25"), or **#931** (fits .965" focuser, accepts 1.25" eyepieces).

$42.95 (3.86)

World's Most Advanced Illuminated Reticle Eyepiece

Series 4000 Plössl 9mm, with rubber eyecup and micrometric X-Y positioning of the reticle within the field. Greatly facilitates locking on the guide star. Sharp high-power imaging, excellent eye relief. Wireless red LED illuminator with adjustable brightness control. Multi-coated optics. **Internal batteries included.** Bullseye reticle. 1.25".

$149.95 (6.14)

Series 4000 Plössl 9mm—Same as above but with 6 ft. cord and plug for Meade LX3, LX5, LX6, LX100, LX200, and APO power panels, in place of wireless illuminator.

$129.95 (5.26)

Series 4000 Photo-Visual Color Filters (1.25")–Premium filters, made of purest crown optical glass, dyed in the mass. For increased contrast and resolution on the Moon and planets. Thread into the barrels of virtually all 1.25" eyepieces sold today. Fully coated.

#8 Lt. Yellow; #11 Yellow Green; #12 Yellow; #21 Orange; #23A Lt. Red; #25A Red; #38A Dark Blue; #47 Violet; #56 Lt. Green; #58 Green; #80A Blue; #82A Lt. Blue

each **$14.95** (2.73)

Set #1–4 filters: #12, #23A, #58, #80A	**49.95** (4.54)
Set #2–4 filters: #11, #25A, #47, #82A	**49.95** (4.54)
Set #3–4 filters: #8, #21, #38A, #56	**49.95** (4.54)

Series 4000 Moon Filter (#ND96): Reduces glare and irradiation during lunar observing. 13% uniform light transmission across the visual spectrum. Threads into 1.25" barrels. **$16.95** (2.73)

#905 Variable Polarizer (1.25")

For glare reduction in observing the Moon. Includes two Polarizer filters mounted in a machined cell and permits continuously variable light transmission from 5% to 25%, to compensate for varying lunar surface brightness according to the Moon's phase and the aperture of the telescope. Accepts 1.25" eyepieces. **$49.95** (5.26)

Electric Focusers for SCT's

For extremely smooth microfocusing of the image. Does not affect use of the manual coarse-focus knob.

#1206 Electric Focuser: Plugs into control panel of Meade 8", 10", 12" LX200 models and operates from LX200 hand controller. **$149.95** (7.48)

#1205 Electric Focuser: For all other Meade 8", 10", 12" SCT models; includes separate hand controller; accepts one self-contained (user-supplied) 9v. battery.

$169.95 (7.88)

#777 Off-Axis Guider for SCT's

Internal prism diverts light for monitoring telescopic image during long-exposure astrophotography. Threads to any Meade or Celestron rear cell. Use with illuminated reticle eyepiece and T-Mount for your 35mm camera.

$79.95 (6.85)

Series 4000™ 2x Apochromatic Barlow Lens

#140: The most advanced Barlow lens available for commercial telescopes, the Meade #140 includes 3-element, multi-coated, air-spaced optics. Doubles the power of any eyepiece with which it is used and yields images absolutely unmatched in resolution, contrast and color correction. The #140 optically complements any telescope — refractor, reflector, or Schmidt-Cassegrain. Accepts 1.25" eyepieces. Mechanical components are of machined aluminum and brass. Lens diameter is 28mm; clear aperture 26mm.

$79.95 (5.26)

Series 4000™ Super Wide Angle 67° field; multi-coated

For exquisite wide-angle images at low-to-medium powers, with pinpoint edge-of-field resolution. Ideal for star fields, galaxies, and other deep-space phenomena. SWA 13.8mm, 18mm, and 24.5mm are superb complements to the #140 Barlow, above.

Super Wide Angle (SWA; 6-elements; 1.25"; 67°)–**13.8mm: $139.95** (4.54); **18mm: 149.95** (4.54); **24.5mm: 179.95** (5.26); **32mm** (2"): **239.95** (7.02); **40mm** (2"): **299.95** (7.02)

Series 3000™ Plössls 50° field; multi-coated

Meade Series 3000 Plössls yield the finest image corrections obtainable from the classical 4-element Plössl design. Focal lengths from 5mm through 25mm are parfocal, so that, at most, only slight refocusing of the image is necessary from eyepiece to eyepiece. Unlike competing moderately-priced Plössls, Meade Series 3000's are **multi-coated** for maximum light transmission and image contrast. Chrome-plated brass barrels are threaded for standard filters. All eyepieces are fitted with fold-down rubber eyecups for comfortable observing. The PL40mm *(far right in photo)*, an excellent complement to any ocular set, produces spectacular low-power, wide fields, ideal for scanning the Milky Way. Manufactured exclusively to Meade optical designs, Series 3000 Plössls yield fine, high-resolution results on reflectors, refractors, and Schmidt-Cassegrains of any focal ratio.

Series 3000 Plössls (4-elements; 1.25"; 50°)

5, 6.7, 9.5, 16, 25mm each: **$49.95** (3.86); **40mm** (44° field): **$79.95** (3.86)

#911B
#910B
#908B
#911N
#910N
#908N

Series 4000 Nebular Filters—Premium multi-layer interference filters, the finest obtainable. Use broadband ("B") filters to block most forms of light pollution; use narrowband ("N") filters in heavily light-polluted areas or for extremely high-contrast observing of faint nebulae.

#908B–Threads into 1.25" eyepieces, 26mm dia.	**79.95** (4.54)
#910B–Threads into 2" eyepieces, 44mm dia.	**119.95** (5.26)
#911B–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia.	**99.95** (5.26)
#908N–Threads into 1.25" eyepieces, 26mm dia.	**89.95** (4.54)
#910N–Threads into 2" eyepieces, 44mm dia.	**129.95** (5.26)
#911N–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia.	**119.95** (5.26)

#911X
#910X
#908X

Series 4000 Oxygen-III Filters Observe diffuse emission and planetary nebulae as you never thought possible! Exclusive Meade *60-layer* interference coating technology isolates the 496nm and 501nm O-III lines to tremendously enhance observable nebular structural detail in all telescopes.

#908X–Threads into 1.25" eyepieces, 26mm dia.	**99.95** (4.54)
#910X–Threads into 2" eyepieces, 44mm dia.	**159.95** (5.26)
#911X–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia.	**149.95** (5.26)

Modified Achromatic Eyepieces

Meade 3-element MA eyepieces yield sharp, well-corrected images on the Moon, planets, and deep-space at a reasonable price. Multi-coated; threaded for filters; 1.25" barrel diameter. Apparent field: 40°. **MA 9, 12, 25, 40mm.**

each: **$37.95** (4.54)

MA12mm Illuminated Reticle Eyepiece

Excellent 3-element optical system, long eye relief, fully coated, with double crossline reticle; rubber eyecup. Wireless red LED illuminator and variable brightness control. 1.25". **Batteries included.**

$99.95 (3.45)

As above but with 6 ft. cord and plug for Meade telescopes with power panels, in place of wireless illuminator. **$79.95** (5.26)

Camera Adapters

Professional-quality adapters for rigid coupling of telescope-to-camera. Use for either Eyepiece-Projection or Prime Focus. Precision-machined of aluminum and brass, threaded for filters. Use with T-mount, available separately.

.965": $27.95; **1.25": $29.95** (3.86)

Variable Tele-Extender

For eyepiece-projection photography with any Meade or Celestron SCT. Threads on to eyepiece-holder. Sliding cell with lock permits wide range of projection magnifications with the same eyepiece. Use with T-mount for your camera.

$39.95 (3.86)

Variable-Projection Camera Adapter (1.25")

Machined sliding cell allows variable projection power in eyepiece-projection photography; permits precise selection of correct photo power in lunar and planetary photography; threaded for filters. Use with T-mount for your camera.

$39.95 (3.86)

T-Adapters for SCT's

Rigidly couples camera to telescope for prime focus photography with any Meade or Celestron Schmidt-Cassegrain. Use with T-Mount for your 35mm camera.

$26.95 (3.86)

CCD-Photo-Visual Flip-Mirror Systems

An essential accessory for imaging with ***any*** brand of CCD imager or for astrophotography with a 35mm camera. Flip mirror "down" to center the image while viewing with an eyepiece at 90°; flip mirror "up" to pass light on to CCD chip or 35mm camera film plane. Each unit includes: precision optical-flat Pyrex® mirror; 2-axis mirror-adjustment screws and locks for precise image centering; extra-fine helicoid focusing of the eyepiece; extension tubes for attaching either 35mm camera (using T-Mount) or CCD imager (using either T-threads or 1.25" barrel). Threads to rear cells of all Schmidt-Cassegrain telescopes; may remain on telescope and used in place of diagonal prism for visual observing as well.

"Over the past 10 years I have used all manner of flip-mirrors. The Meade Flip-Mirror Systems are absolutely the best—rock solid, high-precision, beautifully manufactured; they virtually eliminate all flexture between the CCD and telescope." — Jack Newton

#644 Flip-Mirror System: Accepts any 1.25" eyepiece. Mirror clear aperture: 22mm. Use with CCD's up to Pictor 416XT or ST-7, or smaller; or visual observing with 1.25" eyepieces. **$149.95** (7.02)

#647 Flip-Mirror System: Accepts either 1.25" or 2" eyepieces. Mirror clear aperture: 40mm. Recommended for full-field 35mm astrophotography or with CCD's of any size, including all Meade Pictor Series through 1616XT, as well as ST-4 through ST-8; or for visual applications with 1.25" or 2" eyepieces. **249.95** (8.49)

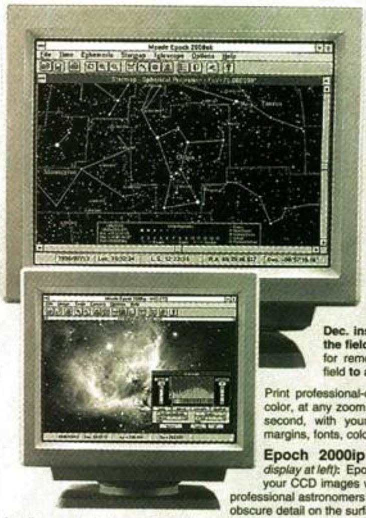
#157 1.25" Adapter: Permits use of either Flip-Mirror on telescopes with 1.25" eyepiece-holders. (Requires approx. 2" additional focus travel with #644, 3" with #647.) **15.00** (3.86)

NEW!
MEADE
FLIP-MIRROR SYSTEM

#644

#647

MEADE
FLIP-MIRROR SYSTEM



Epoch 2000® Sky Software

The most powerful astronomical software ever made available can now be yours for only $149!

Epoch 2000sk *(upper display at left):* Now you can use the most advanced, most precise full-color sky software ever created, to zoom-in on telescopic fields **smaller than one arc second!** With star positions displayed as precisely as **0.01 arc second,** the Trapezium in Orion is no longer shown as a single point, as in other software, **but as four precisely oriented starpoints, just as they appear in the telescope.** No longer do you need to guess the R.A. and Dec. of an object located away from the field center, as in other programs: Epoch 2000sk dynamically reads out the R.A. and Dec. of the cursor position anywhere in the field **and updates R.A. and Dec. instantaneously as the cursor is moved about the field.** Meade LX200 owners can use Epoch 2000sk for remote auto-centering of objects in the telescopic field **to a precision of 30 arc seconds,** routinely!

Print professional-quality star charts in either black-and-white or color, at any zoom setting or sky scale between 180° and one arc second, with your own customized borders, headers, footers, margins, fonts, colors, and grids.

Epoch 2000ip Image Processing Software *(lower display at left)*: Epoch 2000ip makes it easy to enhance and analyze your CCD images with the same sophisticated techniques used by professional astronomers to uncover hidden structure in a spiral galaxy or obscure detail on the surface of a planet. This powerful software includes virtually every technique available for image enhancement. Techniques that bring out detail totally invisible in your original image, transforming it from the ordinary to the spectacular.

EPOCH 2000sk Sky Software: 281,000 objects supplied on 3.5" discs for Windows 3.1 or higher; fully compatible with Windows 95 . . . . **$149**

EPOCH 2000sk-CD Sky Software: 19 million objects, including the complete Hubble Guide Star Catalog; supplied on CD-ROM **179**

LX200 Interface Cable: for Meade LX200 operation by Epoch 2000sk **25**

EPOCH 2000ip Image Processing Software: Supplied on 3.5" discs for Windows 3.1 or higher; fully compatible with Windows 95 . . . . **$199**

4000 f/3.3 CCD FOCAL REDUCER

Series 4000™ f/3.3 CCD Focal Reducer/Field Flattener

NEW!

Revolutionary 3-element Meade design permits ultrafast CCD imaging with **increased** edge-of-field resolution and color correction! Reduces CCD exposure times by up to 80%. Threads on to the rear cell of any Meade or Celestron Schmidt-Cassegrain. Converts f/10 Schmidt-Cassegrain telescopes to **f/3.3** and f/6.3 SCT's to **f/2.** Variable T-Adapter (included) allows range of f/ratios between f/3 and f/5 on f/10 SCT's and between f/1.9 and f/3.2 on f/6.3 SCT's. Use with CCD imagers of any brand and chip dimensions. Not for visual or photographic applications. Multi-coated; 41mm clear aperture. **$149.95** (5.26)

Plössl 25mm Illuminated Reticle CCD Framing Ocular

NEW!
MEADE
PLÖSSL
CCD FRAMING

Displays rectangular frames of all popular CCD chip sizes, including all Meade Pictor models and ST-4 through ST-8. Shows precisely the image size and orientation that appear on CCD chip. Insert directly into telescope eyepiece-holder, or use with Flip-Mirror *(above)*. Includes 4-element coated Plössl optics; lockable spacer ring to fix focus position; rubber eyecup; variable LED illumination control; batteries. 1.25". **$129.95** (4.54)

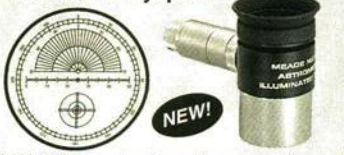
#825 8 x 25mm Right-Angle Viewfinder for ETX®

Permits comfortable right-angle viewing. Replaces standard-equipment ETX finder in seconds, using the same bracket. Wide-angle, achromatic, coated optics; actual field 7.5°. Precise helicoid focusing. **$49.95** (4.26)

#64 T-Adapter for ETX®

Threads to the photo port of any 90mm ETX model and rigidly couples any 35mm camera with removable lens to the telescope for lunar, planetary, or terrestrial photography. Includes extension tubes for either 1250mm (f/14) or 1450mm (f/16). Use with T-Mount for your 35mm camera. **$34.95** (3.86)

MA12mm Illuminated Reticle Astrometric Eyepiece



A high-precision eyepiece for a wide range of astronomical measurements. Includes four red-illuminated, laser-etched scales for measuring double star angular separations, position angles, planetary diameters, and lunar crater diameters, and for long-exposure photo-guiding. Modified Achromatic 3-element coated optics; diopter adjustment; rubber eyecup; variable LED illumination control; batteries. 1.25". **$119.95** (4.26)

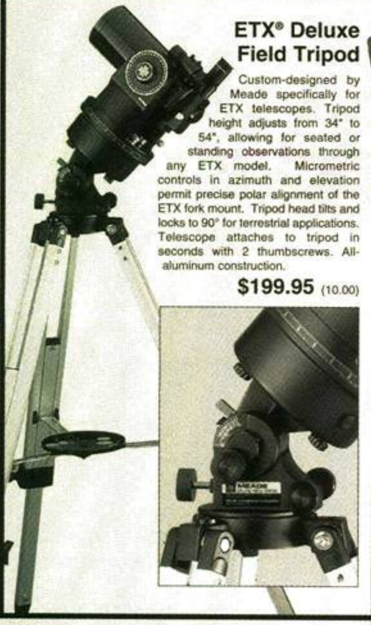
Series 4000™ 8mm – 24mm Zoom Eyepiece

NEW!

MEADE 8mm - 24mm ZOOM

The finest zoom eyepiece available. High-resolution 7-element multi-coated optics, with 55° field at 8mm. Graduated scale in 1mm units indicates exact focal length in use. High-eyepoint yields comfortable observing even with eyeglasses. Internal zoom lenses move on the smoothest, most precisely-machined tracks yet developed for zoom optics. Performance is fully consistent with the finest fixed-focal length eyepieces. Threaded for filters; rubber eyecup; 1.25". **$219.95** (6.38)

ETX® Deluxe Field Tripod



Custom-designed by Meade specifically for ETX telescopes. Tripod height adjusts from 34" to 54", allowing for seated or standing observations through any ETX model. Micrometric controls in azimuth and elevation permit precise polar alignment of the ETX fork mount. Tripod head tilts and locks to 90° for terrestrial applications. Telescope attaches to tripod in seconds with 2 thumbscrews. All-aluminum construction. **$199.95** (10.00)

#774 Hard Carrying Case for ETX®

NEW!

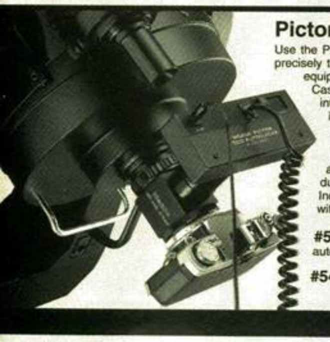
For secure storage or travel with your ETX. Double-wall case plus die-cut foam lining accepts any 90mm ETX model, plus optional eyepieces, erecting prism, table tripod, hand controller, etc. Includes two steel latches with key. **$99.95** (8.58)

#932 45° Erecting Prism for ETX®

For terrestrial observing with any 90mm ETX model. Yields correctly oriented image and convenient 45° observing angle. Threads to ETX rear cell. Accepts any 1.25" eyepieces. Coated roof prism optics. **$49.95** (3.86)

ETX® Carry Bag

Soft-padded Cordura-type carry bag with shoulder strap; permits storage of any 90mm ETX model, plus table tripod legs, eyepieces, other accessories. **$36.95** (5.26)



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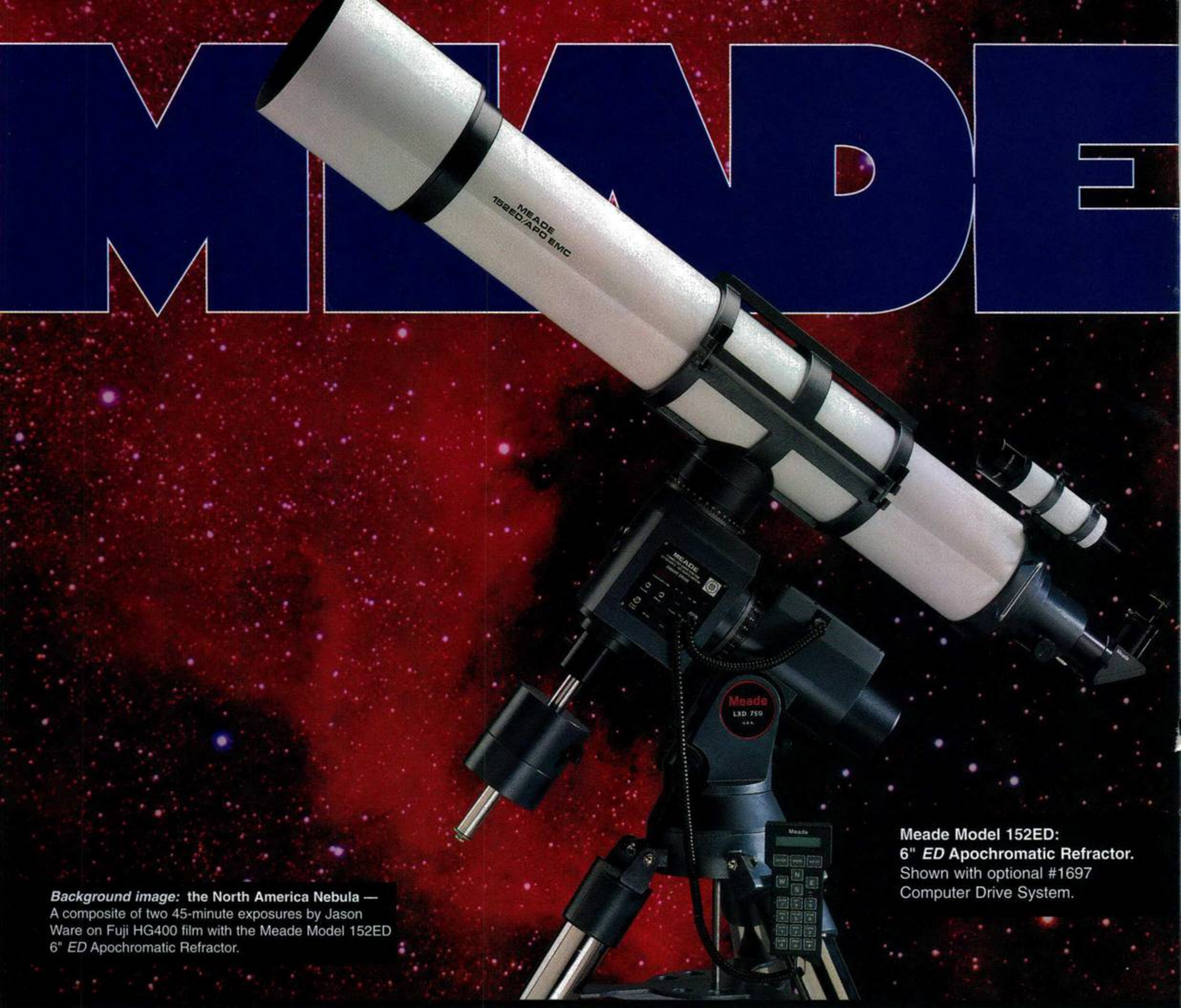

Meade Model 152ED:
6" *ED* Apochromatic Refractor.
Shown with optional #1697
Computer Drive System.

***Background image:* the North America Nebula —**
A composite of two 45-minute exposures by Jason Ware on Fuji HG400 film with the Meade Model 152ED 6" *ED* Apochromatic Refractor.

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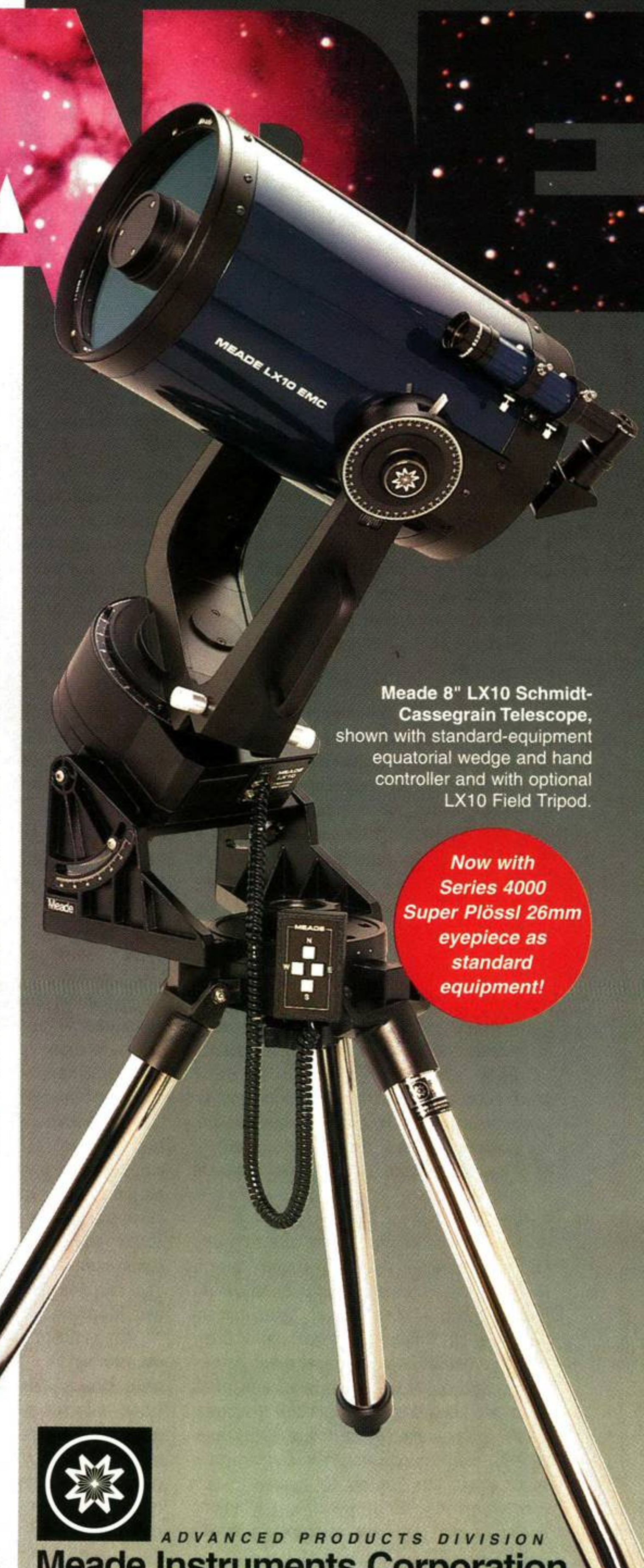

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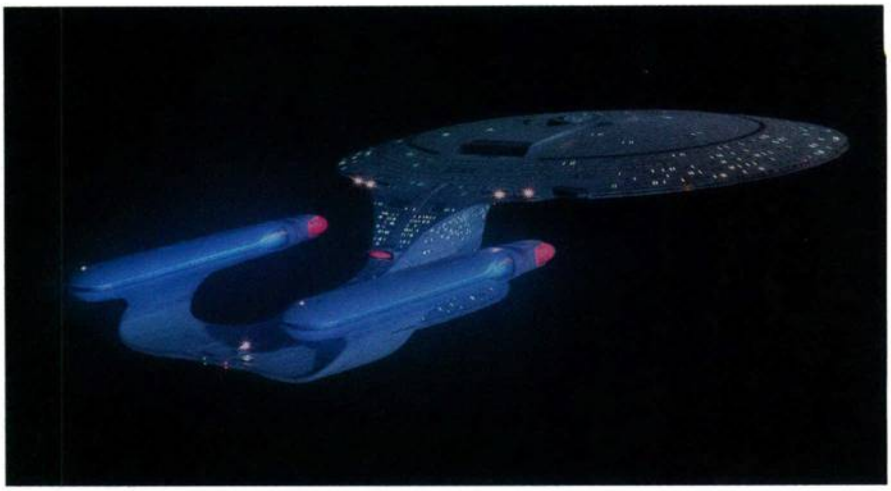
In Defense of Star Trek



Paramount Pictures Corp.

Star Trek **can be thought of as an updated sci-fi version of** ***Animal Farm*** **because it reveals basic truths about ourselves.**

I was impressed with the story in the January issue by Athena Andreadis, "Good Planets Are Hard to Find." I suspect that habitable planets would be rare in this galaxy, and Andreadis clearly explained why such a suspicion is warranted.

However, I think it was a bit unfair for her to pick on *Star Trek*. If the show were to be as faithful to science as possible, it would be boring: 90 percent of the planets the *Enterprise* crew encountered would be lifeless. The show does a better job than most of coming up with believable science while providing an interesting story to millions of viewers.

So they populate their universe with alien cultures and speed up the action with the universal translator. I wince when I see these impossibilities, but I can't fault them for artistic license.

Animal Farm, a classic work of literature, reveals hard truths about ourselves, but it is palatable because animals, not humans, are the characters. *Star Trek* uses alien cultures in a similar way to explore social issues without offending viewers. While the show is good entertainment, it also makes us think. — *Charles DePaul, Lake Geneva, Wisconsin*

We are sure Athena Andreadis likes Star Trek *and we like it very much as well.* — Astronomy *editors*

Lunar Reminder of Calculator's Creator

I read with great interest Paul Hodge's story, "Naming the Man in the Moon," in the February issue. The moon is where almost all amateurs begin. Its surface is much more interesting for the history of science it memorializes than simply for causing the occasional eclipse.

For example, I wonder how many professional astronomers have ever observed one of my favorites, the crater Babbage. It sits in the silent clutches of the moon's surface at 59.7N, 57.1W. Babbage is a 144-kilometer walled plain with crater A and craterlet C nestled within.

Anybody who owns a calculator might like to find it. Anybody who owes their livelihood to calculation, or anybody who sits behind a computer, has Charles Babbage (1792–1871), father of the calculator, to thank.

I believe that scientists such as Babbage, with his mathematical genius and his lunar footnote from astronomy, have enriched our lives immeasurably and made astronomy slightly more enjoyable.

In 1823 he happened on a book which contained the tables for sunrise and sunset. His mathematical mind saw the advantage of calculating such tables. His idea won financial support from the British government. He also invented the railroad cow-catcher and other devices. Yes, Babbage is no ordinary crater and deserves a place beside Struve, Eudoxus, Herschel, Riccioli and Galileo. — *James Husnay, Sr., Syracuse, New York*

Which Martian Mountain Is the Solar System's Highest?

On page 34 of the January *Astronomy*, the caption to a photo of the martian volcano Olympus Mons, with a height of 85,000 feet, calls it "the highest mountain in the solar system." However, within the last year or so, altimetry research of martian features obtained from Viking Orbiter data established that Ascreaus Mons has an altitude of 87,000 feet. — *Gary Finiol, Evergreen, Colorado*

Finiol brings up a good point. Errors in the pre-Mars Global Surveyor topography created uncertainty. Another complication is the qualifier "tallest." Tallest compared to what? There is no sea level on Mars, only a so-called geoid level, but that is going to change, too, with the new gravity data from Mars Global Surveyor, which will begin a systematic mapping of the martian surface this year.

The best bet is, based on present knowledge, Olympus Mons is the tallest mountain in the solar system. — Alfred S. McEwen, director of the Planetary Image Research Laboratory, University of Arizona, Tucson

Where Have You Gone, Quasar 0014+813?

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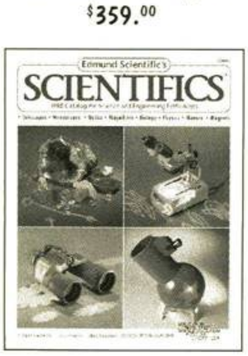

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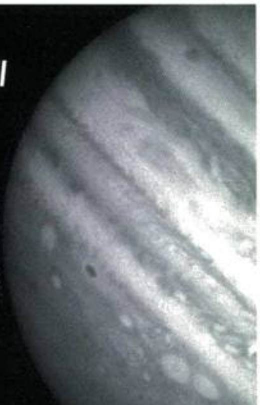

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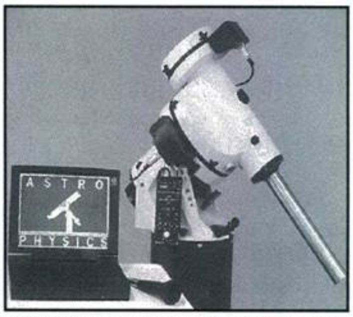

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anticipating new images of the heavens. Hubble and *Astronomy* lived up to expectations. Both are superb.

However, the magazine doesn't always include astronomical coordinates, so it is hard to know where the objects are located. The dimensions of the visible field would be just as valuable. Adding this information would increase the informational value of many images published in the magazine, such as the case of the image of a quasar discussed in "Zooming in on Quasars" in the January issue (page 34). Still, it's just a tiny detail. — *Harry Bego, Utrecht, The Netherlands*

The object you refer to, quasar 0014+813, would appear to be tiny, if you are able to see it at all. Actually, the name of anonymous objects such as this one derives from their locations at the time of discovery: in this case, 00 hours, 14 minutes right ascension and 81.3° declination.

Quasar 0014+813, one of the most luminous quasars known, lies roughly 13.6 billion light-years from Earth. Its magnitude is a dim 16.5, while Pluto's magnitude is more than 100 times brighter at 14. You would need an 8-inch telescope to see Pluto, but you could get by with a smaller one by photographing it. On the other hand, you would need a 25-inch telescope to see quasar 0014+813. It would appear as a faint "star."

If you could see radio waves, the quasar's jets would appear to be about 10 milliarcseconds across. That is a tiny angle. For many of the images we publish in Astronomy, *such information, while available in the scientific journals we usually reference, holds little relevance for many of our readers, so we omit it. Our apologies.*

By the way, the coordinates of astronomical objects change over time because of the slight wobbling of Earth on its axis, which is why the coordinates of deep-sky objects are updated every 50 years. — Rex Graham

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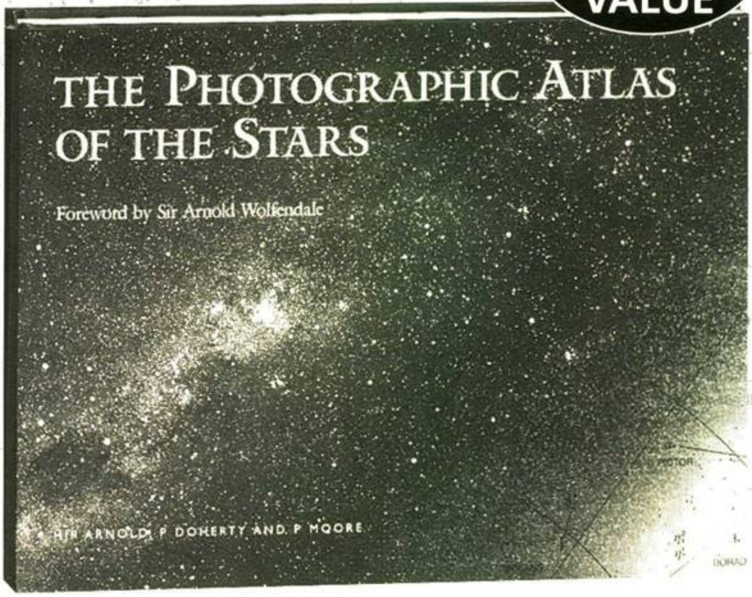
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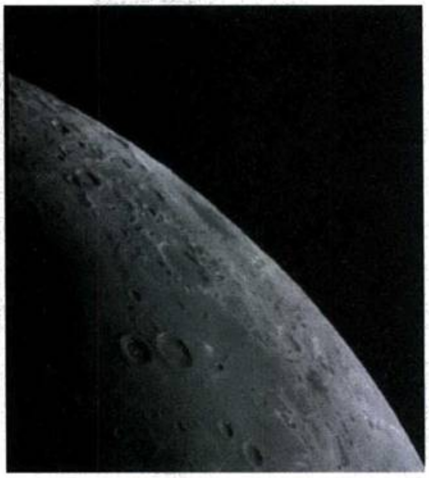

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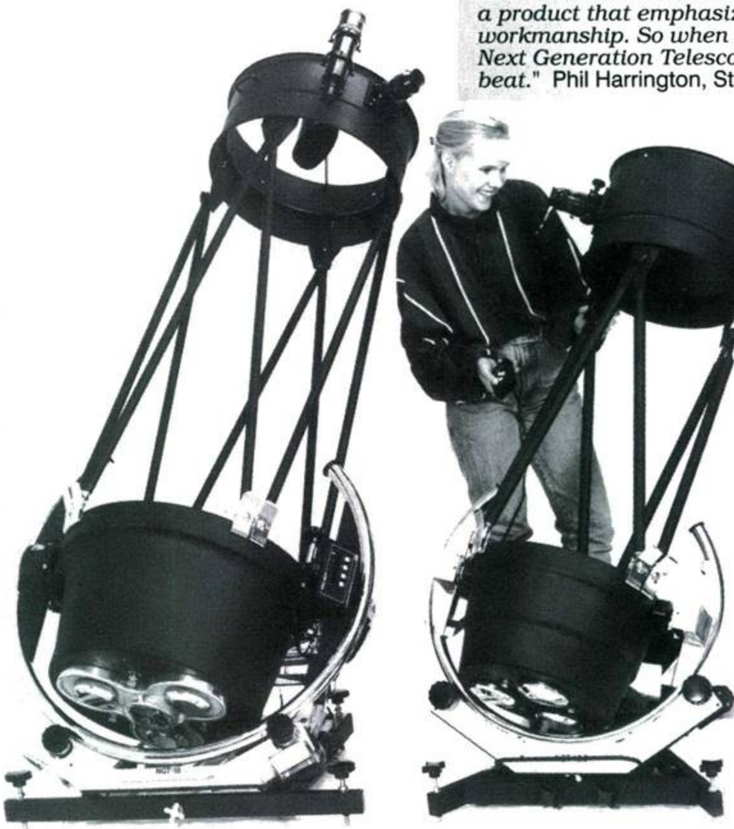

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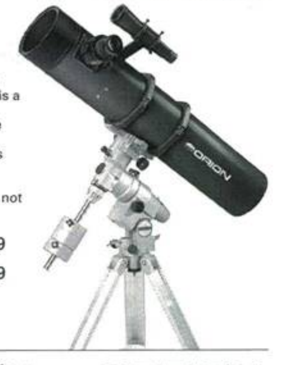

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.965"
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You could pay twice the price for other brands of Plössl eyepieces, but why? Sirius Plössls are top-quality, 50° apparent-field (43° 40mm) eyepieces that yield extremely sharp images of impressively high contrast. Ideal for all types of telescopes. Fully-coated optics, rubber eyeguards. Stock up today!

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EZ Finder™

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NEAR MISSION

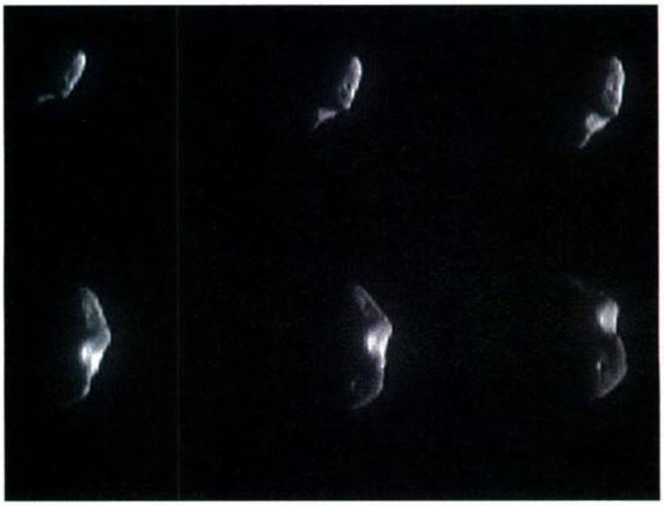
Better Late than Never

▶ An aborted rocket burn prevented the Near Earth Asteroid Rendezvous (NEAR) spacecraft from decelerating into orbit around asteroid 433 Eros on January 10, 1999. But thanks to some last-minute scrambling, NEAR took a series of images and spectra during a December 23 flyby of Eros, and a 24-minute rocket burn on January 3 put the spacecraft on course for a February 2000 rendezvous with the asteroid.

"Right now it looks like we'll be able to do the mission we planned but without any margin for error," says Jim Bell of Cornell University, a member of the NEAR science team.

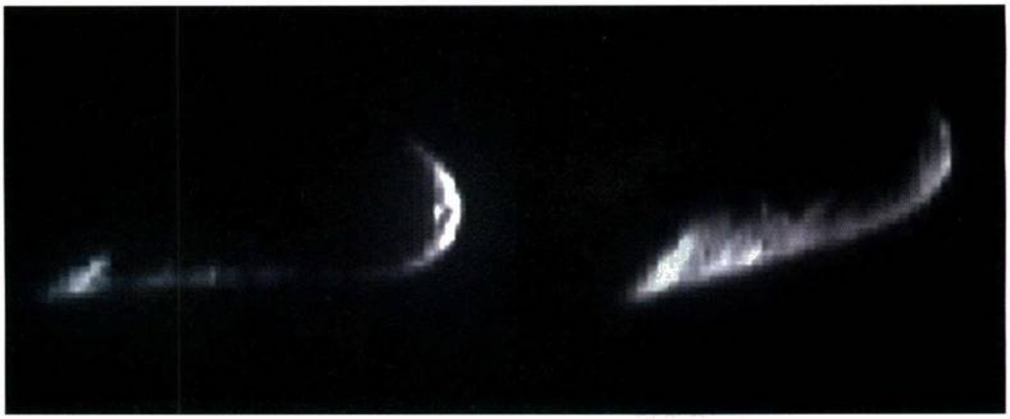
The problems started on December 20 when a software glitch caused the main engine to shut off one second into its planned 20-minute burn. Minutes later, the spacecraft inexplicably went into a violent spin that led to a 27-hour communication blackout. Onboard computers and thrusters stopped NEAR's spinning with no help from Earth, but only after the spacecraft had expended 66 pounds (30 kg) of precious maneuvering fuel.

After contact was reestablished, Ann Harch and Maureen Bell (yes, Jim and Maureen are husband and wife) of Cornell University and Scott Murchie of Johns Hopkins University's Applied Physics Laboratory wrote software that enabled NEAR to observe Eros as it flew by. The software was written and tested in just 24 hours (the process normally takes 6 months) and uploaded to the spacecraft with only 8 minutes to spare.



These images of 18-mile-long (28 km) Eros were taken during NEAR's December 23, 1998, flyby. The six images on the left show the asteroid rotating while the spacecraft was approaching. The two images below show Eros from a range of about 2,300 miles (3,800 km), when the spacecraft was near its closest approach. These are humanity's best views of a near-Earth asteroid, but images taken from Eros orbit starting in February 2000 will be vastly superior.

Scott Murchie/Applied Physics Laboratory



As NEAR zoomed by Eros on December 23, it took 1,026 images. The best images were taken from a range of 2,300 miles (3,800 km), enabling scientists to determine Eros's size and shape, and they established that the asteroid has no large moons. "It's just enough of a tantalizing glimpse to let us know that Eros will have some really interesting geology when we get to see it up close," says Jim Bell. Further analysis of NEAR's radio signal will yield Eros's mass and density, which in turn will help flight controllers prepare for the February 2000 rendezvous.

Flight controllers at the Applied Physics Laboratory later sent commands to NEAR to perform the January 3 burn, which went off without a hitch. NEAR has just enough fuel to maneuver for a full year in Eros orbit as originally planned (see "Ice Cream Sundaes and Mashed Potatoes," February 1999). "We're all very relieved that potential victory was snapped from the jaws of defeat," says Bell.

— Robert Naeye

SLOAN SURVEY

So Far, So Good

▶ The Sloan Digital Sky Survey has wasted no time in breaking old records (see "Stars and Strips Forever," February 1999). After only a few months in operation, the Survey has found three of the four most distant

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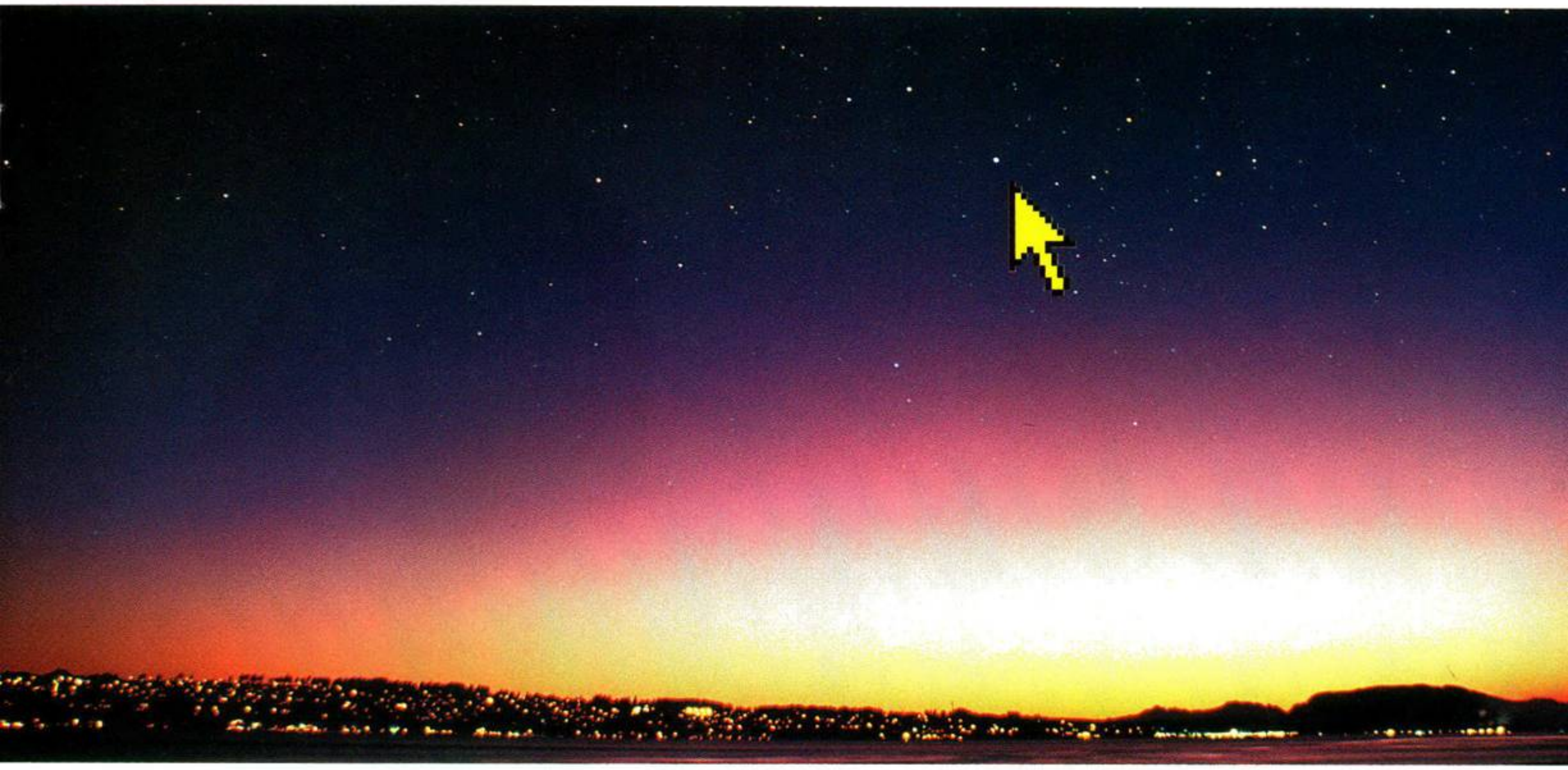

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Ultima® 2000 specifications

8" Schmidt-Cassegrain
2032mm Focal Length
Focal Ratio of f/10
Auto Guider Port
Northern and Southern Hemisphere Operation
Standard 1 1/4" Accessories:
  Multicoated 26mm Plössl Eyepiece (78x),
  Star Diagonal and Visual Back
9x50 Finderscope

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quasars ever observed, including the most distant known quasar in the universe. (Quasars are compact but extremely luminous galactic cores believed to be powered by supermassive black holes.) The Survey had only examined one percent of its projected sky coverage when it encountered these ancient quasars.

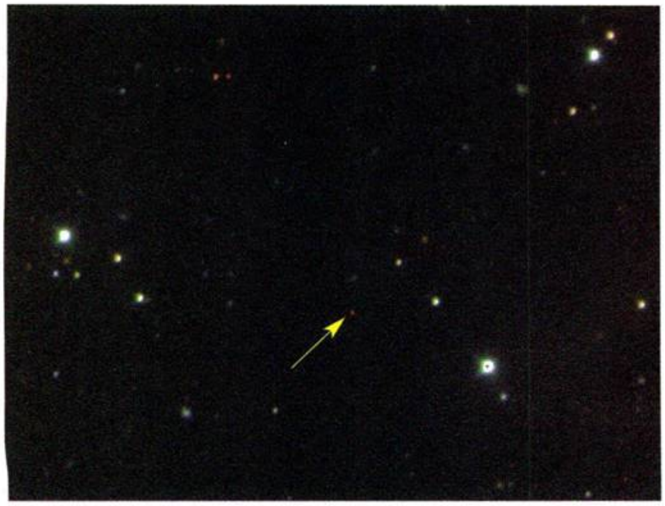
Graduate student Xiaohui Fan and his faculty advisor, Michael Strauss, both of Princeton University, were the first to find and verify the quasars using the 3.5-meter telescope at the Apache Point Observatory in south-central New Mexico. The record-breaking quasars have redshifts (a measure of distance) of 5.0, 4.9, and 4.75 — the oldest dating back to when the universe was less than a billion years old and only one-sixth its current size.

The previous record-holding quasar had a redshift of 4.89 and was discovered in 1991 by Donald Schneider, Maarten Schmidt, and James Gunn. "The results are revolutionary," says Schneider, who is collaborating on the Sky Survey project. "At the current rate of discovery, by the end of the Survey we should find more than 500 quasars with redshifts greater than 4.75."

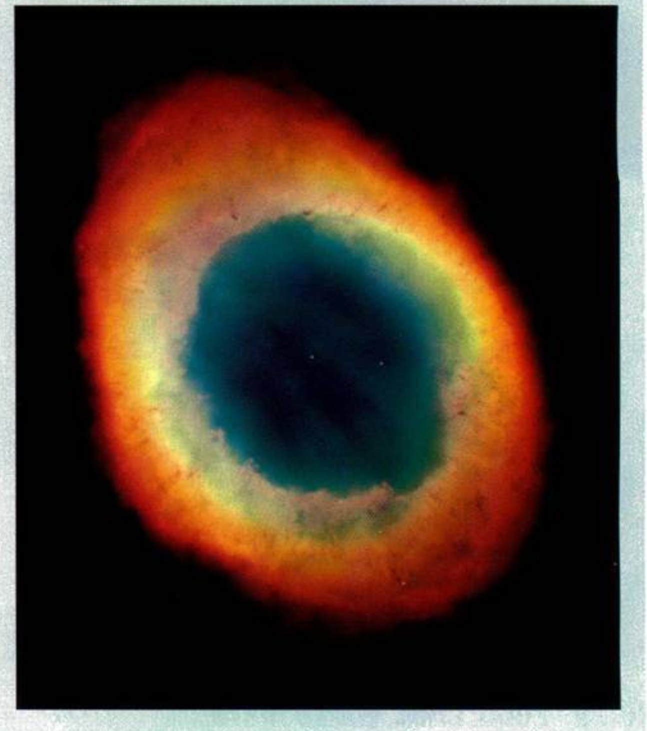
Supernova Cosmology Project team members at the Lawrence Berkeley Lab in California have revealed another record-breaking "most distant" object, a supernova with a redshift of 1.2. Using the 10-meter Keck II Telescope in Hawaii, they found that the light from the exploded star, SN1998eq, took 10 billion years to reach Earth. SN1998eq is nicknamed Albinoni, after the 17th- and 18th-century Venetian composer Tomas Albinoni. Type Ia supernovae, the category to which Albinoni belongs, are helping scientists uncover the existence of the cosmological constant, a property of space-time that causes the universe's expansion to accelerate over time (see "Universe on Overdrive," AstroNews, March 1999).

— Kelly Whitt

The arrow points to the most distant quasar ever observed; it was found by the Sloan Digital Sky Survey. The quasar is so far away that it is barely noticeable despite the fact that it is 100 times as luminous as a typical galaxy. SDSS Collaboration



HUBBLE SPACE TELESCOPE



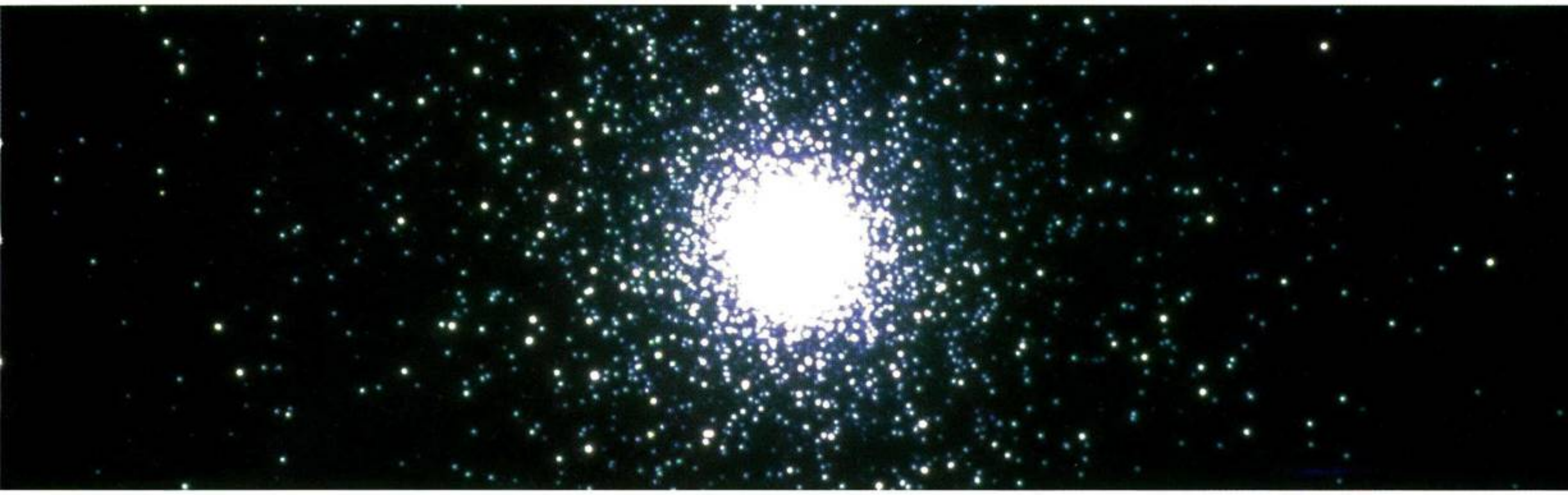
A MAGNIFICENT RING. One of the most beloved planetary nebulae, the Ring Nebula (M57) in the constellation Lyra, gets the Hubble treatment in this latest Heritage Project photo. The image confirms what many astronomers had suspected — that the nebula is actually a cylinder of glowing gas that we view nearly end-on.

Located some 2,000 light-years from Earth and spanning about one light-year, the Ring owes its existence to the faint star seen at its center. When the star ran out of nuclear fuel, it ejected its outer layers, which escaped most easily above the star's two poles, giving rise to the cylindrical shape. If the outer layers had instead come off evenly in all directions to form a sphere around the star, the numerous small dark clouds of dust silhouetted against the bright gas would also extend across the face of the nebula.

The Ring Nebula image marks a first for the Heritage Project, which releases at least one stunning Hubble photo each month. All previous images had been culled from the vast Hubble archives. But in this case the Heritage team received telescope time to obtain a fresh image. The team will receive enough time to take three new photos a year.

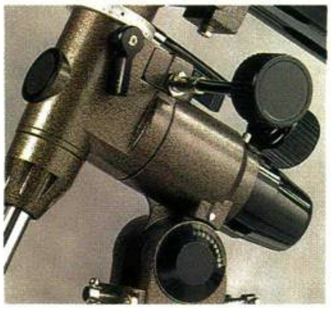
To see more Hubble Heritage images and to vote for future Hubble targets, visit the project's website at http://heritage.stsci.edu. Hubble Heritage Team (AURA/STScI/NASA)

Energy cannot be created or destroyed.



Globular Star Cluster photo courtesy of NOAO.

But it can be stabilized.



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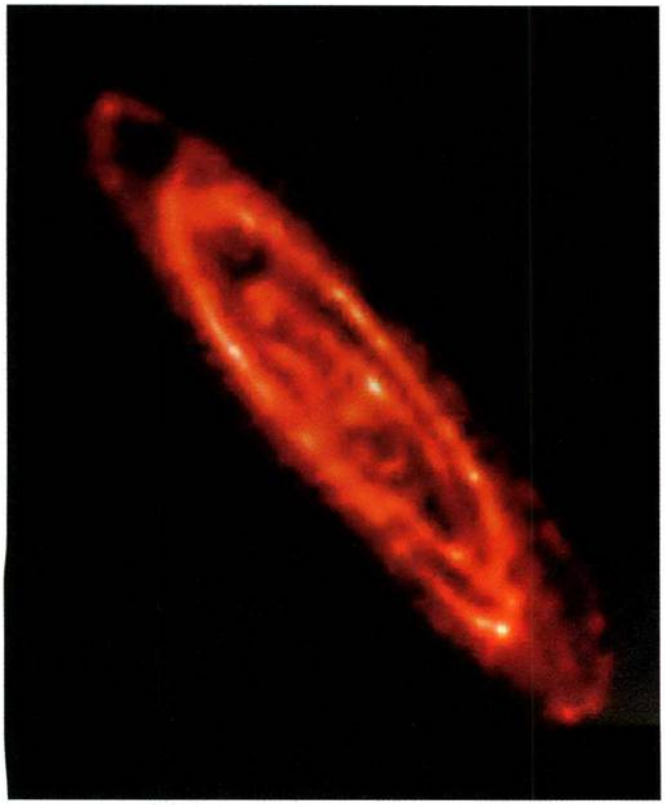
INFRARED ASTRONOMY

Making the Invisible Visible

▶ Strange galactic and stellar rings and "chained" star formation are just a few of the discoveries announced at an October 1998 European Space Agency meeting on the Infrared Space Observatory (ISO).

At the meeting, scientists unveiled an ISO image of a previously unknown series of concentric rings in the Andromeda Galaxy (M31). Conventional optical telescopes cannot see the cold (–430° F) gas and dust that forms these rings. A large fraction of the galaxy's dust and most of the gas is concentrated in the brightest ring. New stars are forming in the structure, which circles the core at a distance of 30,000 light-years (which is about the sun's distance from the center of the Milky Way Galaxy).

ISO also discovered an elliptical ring around the young star HD 97300, some 600 light-years away in the constellation Chamaeleon. Roughly 110 Pluto-sun distances from the central star, this feature is composed of complex organic molecules — the building blocks of life. These molecules are most likely polycyclic aromatic hydrocarbons, or PAHs — the same kind of organic molecules found in the famous martian meteorite ALH84001. The ring is probably made of interstellar material that was swept up by HD 97300's stellar wind.



The Infrared Space Observatory imaged concentric rings of cold dust in the Andromeda Galaxy (M31). Stars are forming inside the rings, the brightest of which circles the core at a distance of 30,000 light-years.

European Space Agency

ISO also peered into the Trifid Nebula (M20), 5,500 light-years away, to find that its massive central star is helping to spawn a second generation of stars. The star's high-energy radiation has affected its surrounding cloud over the past several hundred thousand years, inducing gravitational collapse to form new protostars. The new protostars have masses that range from 17 to 60 solar masses; their high masses mean they will probably spark more star formation when they mature.

Though ISO data continues to make "the invisible visible," in the words of project scientist Martin Kessler, the observatory is no longer collecting data. Its helium coolant ran out on April 8, 1998 — nearly a full year after the expected termination date of May 1997.

— Andrea Gianopoulos

SUNLIKE STARS

Superflares Wrack Sunlike Stars

▶ Don't worry, it won't happen here.

Nine stars whose only common thread seems to be an innate similarity to our sun have generated "superflares" — huge explosions that produce massive quantities of subatomic particles and radiation. The superflares release between 100 and 10 million times more energy than the largest flares ever observed on the sun. They all occurred on what Yale University astronomer Bradley Schaefer calls "perfectly normal stars."

The nine sunlike stars include such naked-eye objects as Omicron Aquilae, Kappa Ceti, and Pi^1 Ursae Majoris. None rotate particularly fast, exist in close binary systems, or are very young — characteristics known to produce similarly large flares in other stars. Schaefer and his team estimate that, on average, one superflare occurs on each of these stars per century.

But it won't happen here.

The researchers note that no superflare has been observed on the sun in the last 150 years of monitoring. But the key reason why none of us should lose any sleep lies in the ancient surfaces of Saturn's icy moons. A large superflare would melt the ice on the daylight side of those moons, creating vast flood plains before freezing smooth. The lack of such flood plains proves that the sun hasn't let loose a superflare in the past few billion years.

Still, it's fun to speculate on what would happen to Earth if the sun produced a superflare. Even the smallest would create aurorae around the world, blow out electronic circuits on every satellite, and black out power grids worldwide. The biggest superflares would give rise to a brief but large temperature increase (making a winter's day feel like summer) and destroy most of the ozone layer, leading to the collapse of the food chain.

So we should thank our lucky star it can't happen here.

Team member Eric Rubenstein of Yale thinks these superflares occur in

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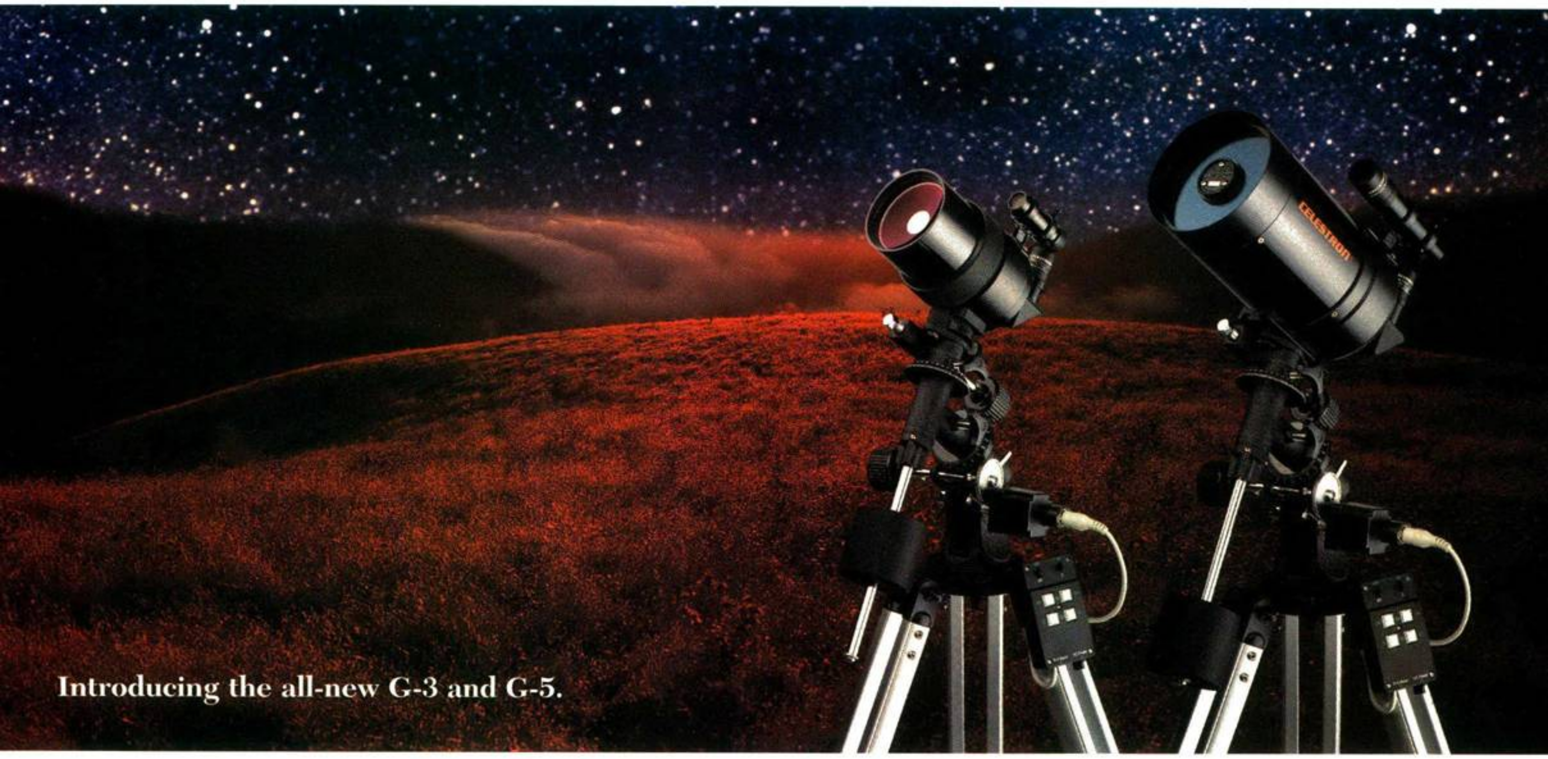

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systems containing a Jupiter-like planet with a large magnetic field in a tight orbit around the star. The interaction between the two objects' magnetic fields stores and then violently releases the huge amounts of energy.

Schaefer and his team reported the results at the January 1999 meeting of the American Astronomical Society in Austin, Texas.

— Richard Talcott

EARLY UNIVERSE

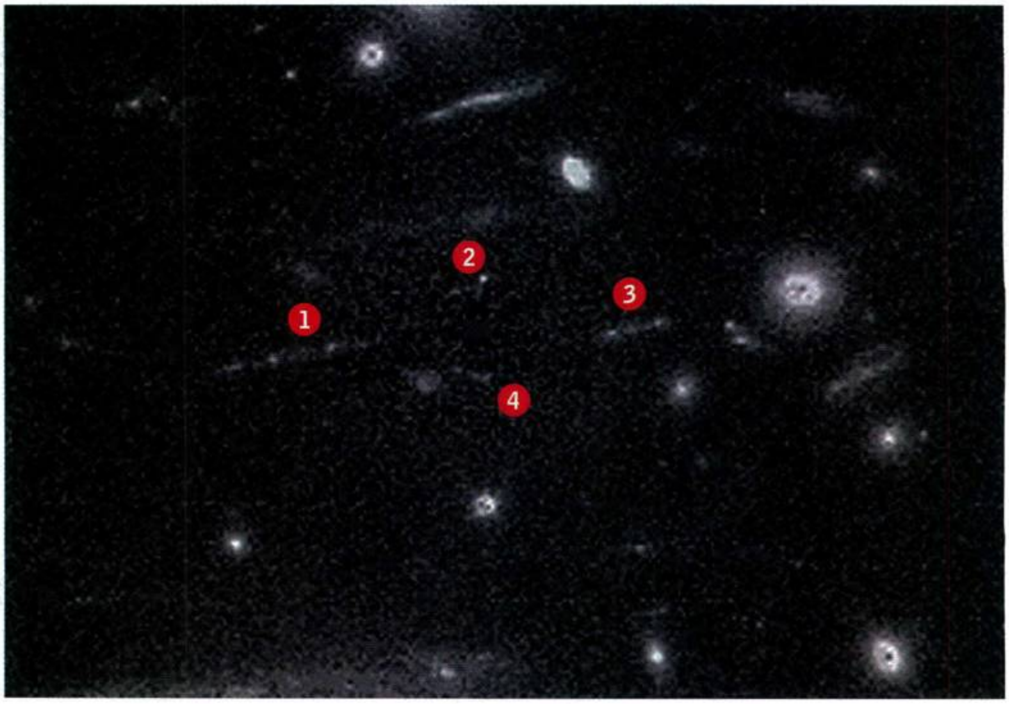
Tiny Primeval Galaxies Packed Wallop

▶ Galaxies just a billion years after the Big Bang were tiny little critters roughly 1/100 the diameter of the Milky Way Galaxy. But thanks to a little help from Mother Nature, astronomers Brenda Frye and Tom Broadhurst of the University of California at Berkeley are finding that these baby galaxies packed quite a wallop — they were seething realms of furious star formation, exploding stars, and powerful winds.

Frye and Broadhurst's findings are based on images and spectra of 10 nascent galaxies taken with the two Keck telescopes in Hawaii. Normally, these galaxies would be far too faint to be seen despite the Kecks' giant 10-meter mirrors. But an intervening galaxy cluster gravitationally lenses the feeble light coming from these distant galaxies, boosting the magnification by factors of 10 to 50.

Spectra reveal that the gas in these mini-galaxies is highly blueshifted with respect to the surrounding stars, meaning that gas is moving toward Earth at speeds up to 1.7 million miles (2.7 million km) an hour. Dark lines in the spectra betray the presence of heavy elements such as carbon, oxygen, and silicon.

A single supernova couldn't create these winds or the plethora of heavy elements. Clearly, these galaxies must have been producing stars at a furious rate, with the most massive stars forging heavy elements and exploding as supernovae at roughly the same time and place. The winds of these supernovae probably combined to form "superbubbles" of expanding gas. Some nearby galaxies are undergoing a similar phase, but as Frye says, "The difference here is that every single one we find in the early universe has a gas outflow, but only a small fraction of them now have gas outflows. So it was a much more violent time."



In this Hubble Space Telescope image, a single distant galaxy has been gravitationally lensed by a galaxy cluster into four arcs (numbered). Spectra taken by the Keck telescopes show that the galaxy is spewing winds enriched in heavy elements. Brenda Frye and Tom Broadhurst (University of California at Berkeley)

The winds from these distant galaxies are moving fast enough and contain enough heavy elements to pollute the vast empty regions between galaxies with heavy elements in just 300 million years. This would explain why intergalactic space contains a surprisingly high abundance of heavy elements.

THE SUN

A Solar Gesundheit

▶ Though the cold and flu season may be waning, the sun's "sneezes" continue to intrigue NASA scientists. The agency's Advanced Composition Explorer (ACE) spacecraft recently determined a temperature of 18,000,000° F for these solar sneezes — small, spontaneous explosions on the solar surface. Because high temperatures can strip atoms of their electrons, the resulting positively charged ions are used to determine the flare's temperature. As the temperature increases, so does the loss of electrons.

Not only is the sun known to sneeze, but researchers from the University of Alabama at Huntsville led by S. T. Wu used an instrument on the Solar and Heliospheric Observatory (SOHO) to find that the sun is "puffing" vast clouds of ionized gas into the solar system. This added material may explain why the solar wind is unsteady. "It equals to about 100 kilograms per second pounding on Earth," says Wu. "This pounding affects Earth's magnetic field and

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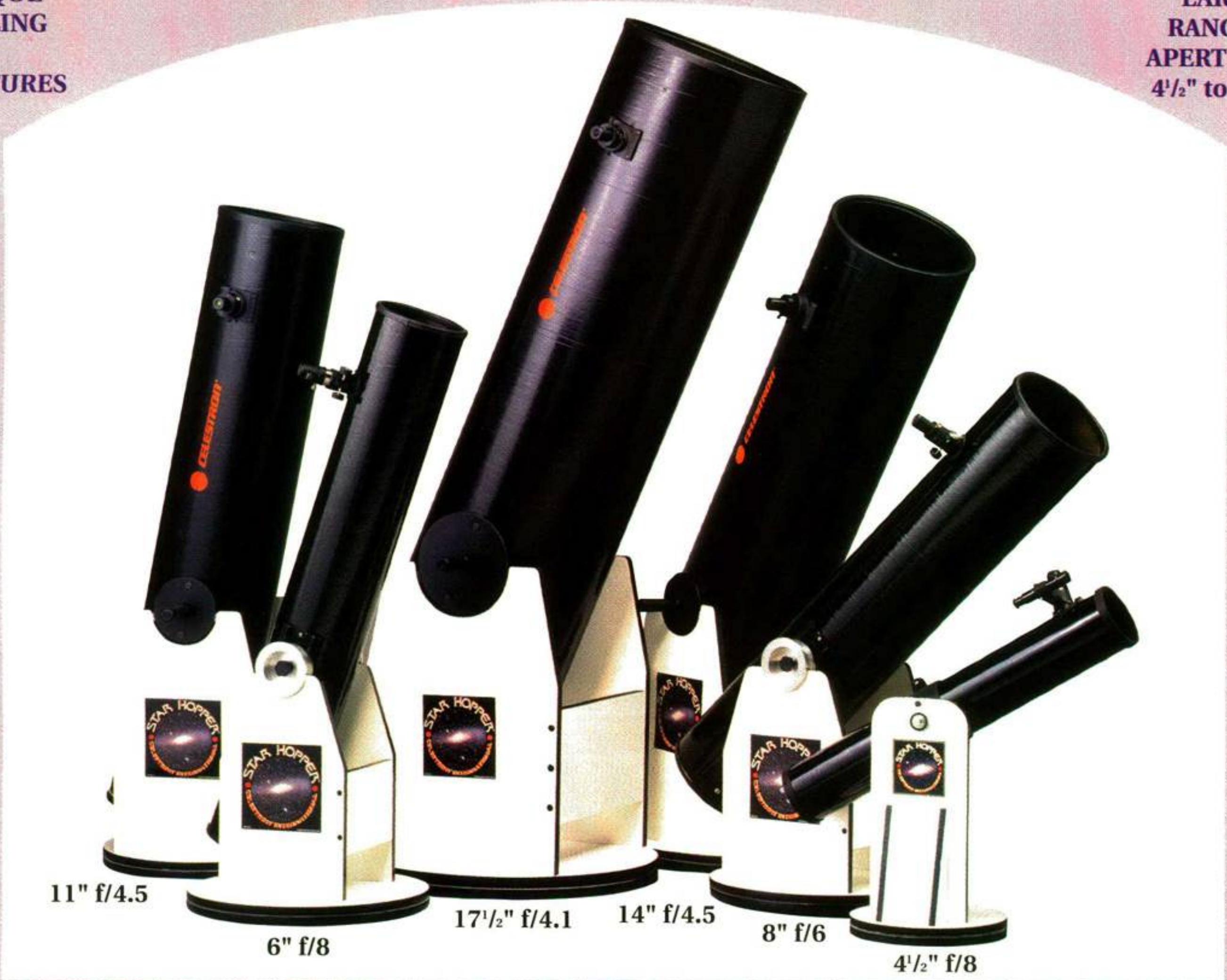

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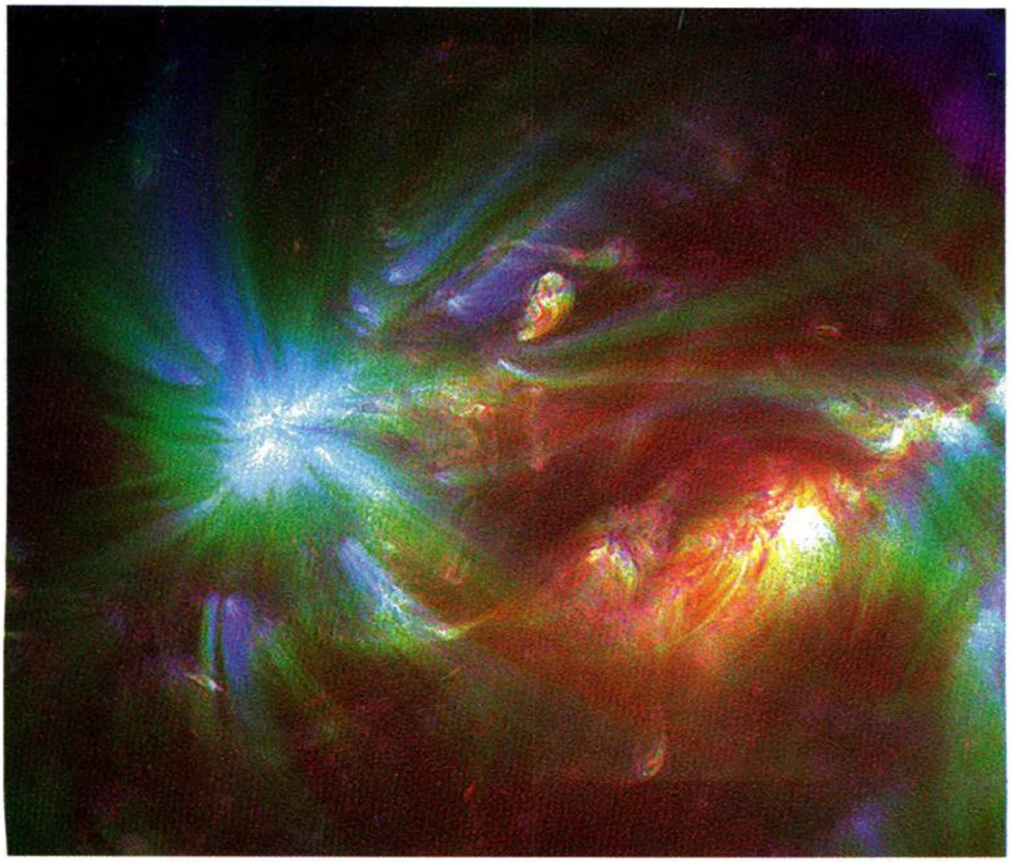
Celestron International • 2835 Columbia Street, Torrance, CA 90503 • (310) 328-9560 • FAX (310) 212-5835 can induce magnetic storms."

Solar prominences (vast eruptions of gas) are also revealing some of the sun's secrets. In the December 3, 1998, *Nature*, Jack Zirker of the National Solar Observatory in Sunspot, New Mexico, reported finding "counter-streaming gas flows" in a solar prominence. Zirker and his colleagues have identified individual knots of material flowing in opposite directions between the sun's chromosphere (the layer just above the sun's visible surface) and the prominence. Because the flows must be aligned with the sun's magnetic field, this observation suggests that the magnetic field connects the prominence directly to the deeper photosphere, a link that conflicts with existing models. According to Zirker, "These magnetic 'tethers' might help prevent a prominence from erupting."



In this top-down view of an active solar region from NASA's TRACE satellite, the sun's strong magnetic fields rein in loops of hot plasma. The false colors represent different temperatures: Blue is 360,000° F, green is 900,000° F, red is 2,700,000° F, and white represents a combination of all three colors.

Alan Title/Stanford Lockheed Institute for Space Research and NASA

NEW SATELLITES

Water, Water Everywhere

▶ Initial observations from NASA's newest astronomical satellite show that the material between the stars is saturated with water but contains little molecular oxygen. Rocketed into space from an airplane on December 5, 1998, the Submillimeter Wave Astronomy Satellite (SWAS) became the first space-based observatory to operate in the band of emission that lies between infrared and radio wavelengths.

In just its first two weeks of scientific operation, the satellite targeted five molecular clouds — regions where stars and planets are born. What it found was water, and lots of it. "We have seen water in the interstellar medium before, but only in hot regions," says principal investigator Gary Melnick of the Harvard-Smithsonian Center for Astrophysics. "SWAS, on the other hand, has found water in much cooler regions, and that's important because most of the interstellar medium is very cold."

Astronomers suspect that water plays a huge role in forming stars out of molecular clouds. As a cloud begins to collapse under gravity, it heats up. But long before stars could form, the outward pressure from the warming gas would balance the inward pull of gravity, stopping the collapse. That's where water comes in. Collisions between molecules in the cloud excite electrons in the water molecules, which then radiate away that energy. The radiation — what SWAS sees — helps cool the cloud and allows the collapse to continue.

Equally exciting, SWAS has yet to detect any molecular oxygen. "Molecular clouds are like chemical laboratories," says Melnick. "Our theories tell us oxygen won't appear until the clouds reach a certain age." With a limit of no more than a few oxygen molecules out of every million, the clouds observed so far can be no more than a few hundred thousand years old.

MASSIVE STARS

Stellar Powder Keg

▶ Wolf-Rayet stars won't be choice destinations for future interstellar tourists. These hot, massive stars are going through a brief but violent transition phase before exploding as supernovae. As they near the end of their lives, these powerful stars belch out enormous

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quantities of gas in the form of rampaging stellar winds.

In a recent image, the Hubble Space Telescope resolved individual blobs of gas being shot out of a Wolf-Rayet star — the first time such structures have been directly imaged in visible light. The blobs are zooming away from WR124, 15,000 light-years away in Sagittarius, at more than 100,000 miles an hour. Each blob contains about 30 Earth masses and spans about 100 billion miles, roughly 27 times the Pluto-sun distance.

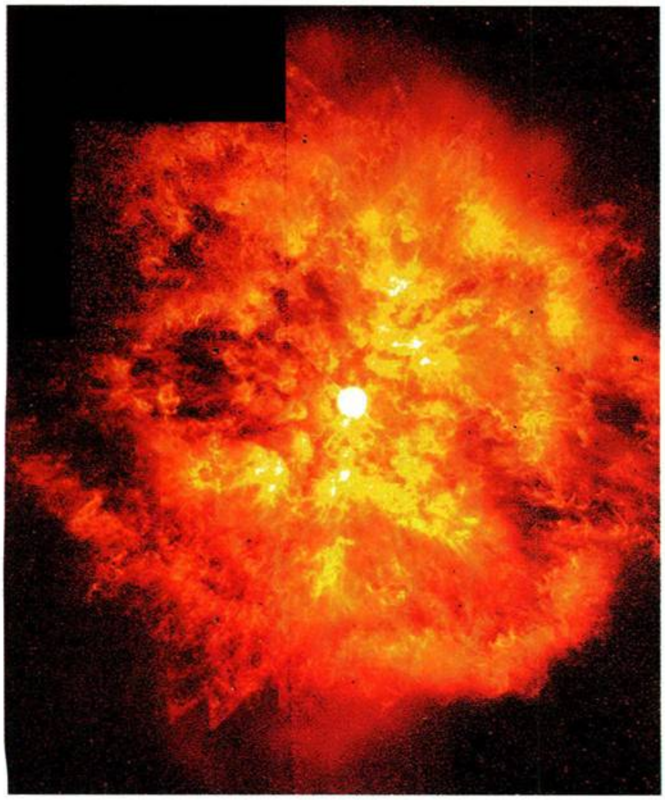
The image also shows vast filamentary arcs of glowing gas surrounding WR124. Unlike nebulae seen around many Wolf-Rayet stars, these arcs don't form an overall circular shell. "We believe we are actually seeing the wind itself before it collides with the surrounding interstellar gas. This produces a series of arcs of different sizes with no overall coherent structure," says Anthony Moffat of the University of Montreal, one of the team members who took the Hubble image.

If this scenario is correct, instabilities in the star's atmosphere, rather than interactions with the surrounding interstellar gas, would be responsible for the chaotic and lumpy nature of the stellar wind.

WEBSITE

Check *Astronomy*'s website for news as it happens — http://www.astronomy.com.

This Hubble Space Telescope image shows a massive Wolf-Rayet star belching out large blobs of gas. This is the first time such blobs have been directly imaged in visible light. Yves Grosdidier (University of Montreal), et al., and NASA



AXAF Is Rebaptized

Following the tradition of naming NASA's Great Observatories after luminaries in the field of astronomy (e.g., Edwin Hubble and Arthur Holly Compton), the Advanced X-ray Astrophysics Facility (AXAF) is being renamed in honor of the late Subrahmanyan Chandrasekhar, a Nobel Prize-winning astrophysicist born in India. NASA chose the name "Chandra X-ray Observatory" from over 6,000 contest entries. Chandrasekhar (or Chandra, as his friends called him) is best known for his discovery of the 1.4 solar-mass upper limit of white dwarfs. The Chandra X-ray Observatory will be the third of NASA's four "Great Observatories."

NASA Roundup

NASA has had its ups and downs. On January 3, 1999, Mars Polar Lander successfully launched into a cloud-covered Florida sky. The spacecraft will touch down near Mars's southern polar cap on December 3, 1999 (see "Divining on Mars," February 1999). On December 21, 1998, the last of the Solar and Heliospheric Observatory's (SOHO) three gyroscopes failed. But mission managers are confident they can operate the $1 billion spacecraft without the gyros. In other NASA news, the Hubble Space Telescope's infrared camera NICMOS ran out of coolant in early January 1999 and is no longer functional. But Space Shuttle astronauts are scheduled to install a new cooling system during the third servicing mission in May 2000. This new system should bring the camera back to life.

This image from SOHO's Extreme-ultraviolet Imaging Telescope shows a prominence large enough to span 28 Earths. SOHO-EIT Consortium and NASA/ESA

Scientific Research Pays

The McDonnell Foundation has awarded $1 million each to 10 young research scientists whose work is expected to "contribute substantially to the development of knowledge and its responsible application." In the category of astrophysics and cosmology, the beneficiaries are Christopher Stubbs of the University of Washington, who designed and built a camera used to study gravitational lensing, and John Carlstrom of the University of Chicago, whose research helped draw conclusions about the mass density and ultimate fate of the universe.

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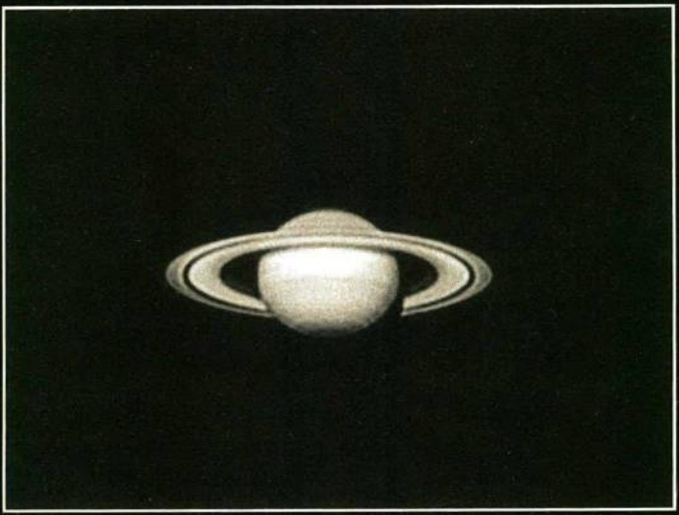

***Saturn.** This remarkable ST-5C image was taken from the rooftop of the observer's apartment building using a 10"f/10 SCT and 2X barlow. The image clearly shows the Cassini division, Encke gap, inner crepe ring, brightening in the ring structure and atmospheric detail on the planet. Courtesy Antonio Jose Cidadao, Member of A.P.A.A (Associaiacao Portuguesa de Astronomos Amadores).*

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A fearless, quarter-century deep look into the future of the solar system.

To help celebrate our 25th anniversary last year, the editors of *Astronomy* gathered ten of the world's premier planetary scientists for a forum. The questions spanned the topic of what will happen in solar system astronomy over the coming 25 years. The answers, which came during a three-hour session in Madison following last year's Division of Planetary Sciences meeting, may surprise you. If this article whets your desire, see the full text of the session at: http://www.astronomy.com. We thank our participants: James Bell (Cornell), Imke de Pater (University of California), David Grinspoon (University of Colorado), Heidi Hammel (MIT), William K. Hartmann (Planetary Science Institute), Renu Malhotra (Lunar and Planetary Institute), Karen Meech (University of Hawaii), Carl Pilcher (NASA), Carolyn Porco (University of Arizona), and Alan Stern (Southwest Research Institute).

Lynette Cook

Text by David J. Eicher and photographs by Jim Forbes

Right: Carolyn Porco looks forward to a rapidly expanding encyclopedia of solar system knowledge. Will we detect life elsewhere in the solar system? "If it's completely different from what's on Earth," she suggests, "we may not be able to recognize it." **Below right:** Cornell's Jim Bell. **Bottom right:** UC-Berkeley's Imke de Pater.

LIFE IN THE SOLAR SYSTEM

Astronomy: In 25 years, what will we know about life in the solar system?

Hartmann: Fearless forecast: We'll know a lot more about microbial life, particularly below the surface of Earth, which is really a field that's developing rapidly right now.

Porco: I think the discussion about life in the solar system in 25 years will be very much the same as it is now. We'll have more facts. We'll have been to Titan, certainly with Cassini and the Huygens probe by then, and we'll see in a rudimentary way what kind of chemistry is taking place on the surface. We might even have some kind of robotic presence on Titan. But, fundamentally, I think there's a conundrum. We only understand the life that's at the surface of this Earth, so what if we find organisms or chemistry, say on Mars, that looks similar to what's on Earth? Did it get transported from Earth? Or did it originate on Mars? And if it's completely different from what's on Earth, we may not be able to recognize it. Either way, it will be a difficult question to tackle.

Astronomy: It seems that the call thus far has been, where there's water, there might be life. Are there other signatures to look for?

Grinspoon: I think that the hypothesis, "where there's water, there's life," is one that we will have tested 25 years from now. For example, we'll quite possibly have begun to explore an ocean on Europa. It will be very interesting to see what the results are. I agree with Carolyn that the discussion then will be very similar to the one we're having now. It's unlikely that we'll find something that really is a signature of biology elsewhere in the solar system. This doesn't mean we shouldn't search. It's an unlikely event, but if it does happen it'll be profoundly important.

Malhotra: I could draw an analogy from a simpler system. The extrasolar planets thus far discovered are unlike anything we were expecting, quite unlike our own solar system. Now that we've found them, our imagination has been expanded. My guess is that a similar expansion of imagination will take place with whatever life may be found.

Stern: I think we should have a pretty definitive answer about Mars. We'll bring back dead bodies or live bodies, or chemical evidence of one kind or another.

Hammel: If you're restricted to chemical signatures, you're going to be fighting a very tough, uphill battle to convince people you've got life. People got very excited about the ALH84001 meteorite because of these little ovoids, little wormlike structures, and they could sort of hang their hats on that. If you're talking a chemical signature or even a pocket of self-replicating molecules, that's a tough sell for life.

Pilcher: On Mars, if we spent all our time sampling rocks, then the statement that it's going to be ambiguous unless we get lucky is absolutely right. But if we can get down to an aquifer, and assuming that aquifers are connected, if you pull up water without a significant reduction of carbon in it, then you can probably start making credible arguments that there really isn't anything biological going on on this planet. At least we'll have something of a foundation for this argument. On the other hand, if you pull up something that's got lots and lots of dissolved carbon in it, whether or not it's got a bug in it, you're going to say, "Hey, there's a smoking gun here, let's find out more."

Hartmann: There are 25 years of good work to do on conventional life. We know of organics in carbonaceous meteorites, and we're going to want to know whether they ever get together and make proteins, and so forth. We're going to be looking for fossil microbes in Mars rocks, and we're going to be looking for other types of organic materials in Mars rocks,

Mars soils, and Mars water. We're going to be looking at Titan, Europa, meteorites, asteroids, and comet samples. There's a road that we're led down by what we already know. Even if that road is a dead end, we're going to gain fantastic new knowledge.

de Pater: If life originated in a comet, then finding it in other locales in the solar system is likely. It's a logical first step to look around for life similar to us while keeping our eyes open for other types.

Astronomy: How would you go looking for life that wasn't carbon based?

Grinspoon: If it's complex life I think it will have macroscopic fractal forms — irregular shapes that repeat at any scale by which they're examined — as complex life on Earth does and that we'll recognize it as being from biological properties. Complex life will be recognized as being alive by its shape. Simple life — single-celled life — will be pretty hard to recognize, but we'll look for its thermodynamic properties.

Porco: Unless, of course, we catch it in the act.

Chorus: [laughter]

Grinspoon: Reproducing and excreting and eating and modifying its environment and using energy gradients and those kinds of things that life does — those are good clues.

Astronomy: If in 25 or even 50 or 75 years we have a negative answer for extraterrestrial life in the solar system, what would that imply for the galaxy?

Chorus: Probably not much.

Hammel: It proves that we're not clever enough yet.

Astronomy: Is there likely to be a happy medium between life being really rare and finding it all over the place?

Porco: A negative answer will simply suggest that you have a very limited range of habitable zones in which life can originate. But the numbers are so huge to begin with that there are probably lots of places in the galaxy where you can have even limited habitable zones around stars.

Hartmann: Something we know from the microbial research is that most life is a bunch of little stuff, slightly larger than groups of molecules in the microbial world, and that big things like us are a real anomaly. If you take it from a numerical standpoint and look at us as the tip of the iceberg and fly around the galaxy looking for life, then it's clear that 99 times out of 100 all you're going to find are little microbes. We all come at this with the idea that life means Star Trek-like worlds with civilizations with councils that operate on democratic-like principles, and that isn't the way it is.

OTHER SOLAR SYSTEMS

Astronomy: What will we know about other solar systems 25 years from now?

Grinspoon: We'll certainly know about the giant planet distributions of many other solar systems and that implies a lot about terrestrial planets.

Hartmann: As we discover more planetary systems, are they in coplanar orbits? That would be the real smoking gun for a system that has formed like our system.

Stern: Recently it became clear that one of the mechanisms for getting large planets in close is to have an unstable system that cools itself off by scattering energy. The analogy was immediately made to galaxies, which evolve over time. So we may see many very disruptive systems that don't look at all like they did initially.

Hartmann: And probably our

Karen Meech

Left: **Karen Meech looks forward to comet research: "We're going to make huge progress in this area, getting a look at the formation of distant comets and Kuiper belt objects."** **Above left:** **The Planetary Science Institute's Renu Malhotra.**

Right: "We are . . . in the entertainment business," says Alan Stern. "We're enlightening people's lives and providing something larger than life." **Below right:** The University of Hawaii's Karen Meech.

solar system does look like it did initially, because you can see the compositional structure, the zonal structure. . . .

Stern: Yes, but these other systems completely destroy the initial architecture.

Malhotra: We must have a little sense of disappointment. More than 100 sunlike stars have been observed and only 3 or 4 percent seem to have Jupiter-like companions. The vast majority of sunlike stars seem not to have such companions. Possibly it's too early to call this disappointing, but at this point, while there are apparently planets around other stars, the ones we know about so far are quite unlike our solar system. But 25 years from now we may know much more about this question — it may be relatively unambiguously answered on that timescale — of how normal or abnormal our solar system is.

Stern: The very first extrasolar planet discovered was around a pulsar, and in fact because of the exquisite ability to do radial velocity measurements, we know there are Earth-mass objects in that particular system.

INTELLIGENT LIFE

de Pater: There will be a lot more data coming from the large radio telescopes used in SETI, which have had this really odd history after being thrown out of NASA, basically, and I think we should not overlook the high level of enthusiasm from the public for SETI. When Jill Tarter gives a talk, the room is packed.

Stern: The earthlings are rooting for life.

Chorus: [laughter]

Bell: But there's a disconnect there between what NASA wants to support and what the public wants.

Pilcher: NASA in some ways needs to be conservative, because there are elements of our society that are afraid of such a discovery. NASA didn't throw out SETI, by the way.

Chorus: Congress did. [laughter]

de Pater: But it's not funded by NASA anymore, as I understand. . . .

Pilcher: That's not by choice at NASA.

Grinspoon: There are a lot of voices within Congress that are very critical of SETI and give NASA a hard time over it.

Porco: I think that's going to be the greatest psychological cataclysm, when and if we encounter any signal from intelligent life in the universe, that will eclipse any blip of enthusiasm over the ALH84001 meteorite.

Hammel: You used the word intelligent life . . . everything we've been talking about so far has been life, not intelligent life. I absolutely agree that it will be an absolute social cataclysm when that happens.

Porco: I can't wait.

Chorus: [laughter]

Stern: Remember that the distances are so large that unless they're showing up, I expect there will be a fundamental change in the philosophical way we look at ourselves, but two weeks later it won't be the top story on the news every day. Life will be back to normal. . . .

Grinspoon: Unless there's the possibility of two-way communication, which is much less likely — so we might know about them but won't have the capability to find out how to make better machines or exchange favorite recipes.

Stern: Carolyn kicked this question around earlier about it being hard to recognize life. I think it's going to be even harder to recognize intelligence. We can't define it on our own planet.

Chorus: [laughter]

Stern: *It may* be very difficult. Talk about chauvinism, we're looking for radio signals. And it may not be encoded in radio waves. We shouldn't rule out intelligent whales on Europa . . . it's within the laws of physics.

Grinspoon: A species is intelligent if it's capable of not destroying itself. This means that it's not clear that humanity has passed that hurdle.

Stern: By that definition, oak trees are intelligent.

Chorus: [laughter]

Grinspoon: Okay, surviving with technology and not destroying itself.

Malhotra: There used to be a working definition of intelligent life of "life that modifies its environment," and by that definition ants are intelligent life.

Porco: Hot water modifies its environment.

Astronomy: What will happen to planetary astronomy if life is found outside the solar system? Will that move the focus away from searching for life on Mars?

Hartmann: I think it boosts everything, because you have better statistics in twos, so to speak, so that you can compare as many similar worlds as possible — each example is one of nature's experiments. I would predict more support for planetary astronomy.

DECIPHERING MARS

Astronomy: What will we learn about Mars, and what will we discover in other areas of martian research from the upcoming Mars missions, aside from the whole question of life?

Hartmann: Well, I would say there are two big mysteries. Why did the climate change? There seems to be evidence that it was very different in the past, and that mystery segues exactly into the second: If the climate was different and there was water, was there life or was there no life? If there was life, what was it like? If not, why not? How long were the rivers active? Were they only active for some period at the beginning when there was a thick atmosphere? Or were there episodes when everything warmed up and then got colder? And so on.

Bell: I worry a little about subsurface aquifers. We have a program to go to Mars but it's really, quite literally, scratching the surface. To get down into the aquifers, to find the water, is going to require an order of magnitude more in terms of technology and funding than what we have right now.

Astronomy: Can you even look deep underground on Mars with robotic missions, or would that require humans on the surface?

Bell: Now we're talking about setting up a drill rig.

Pilcher: Well, color me the incurable optimist, but I think we're going to make that leap, and I can see the path. We put up an aerostationary communications satellite, maybe two or three of them, and that will enable people to access information from Mars at a rate faster than they can get data off their computers today. From remote sites, they'll be able to experience Mars. The scientists will be working in real time. I think we will make that leap and we will have drill rigs on Mars in 25 years.

SCIENCE VS. ENTERTAINMENT

Malhotra: Is this about entertaining the public?

Pilcher: I think we need to stop seeing that as a sort of dirty word and selling our souls, and I think we have to start recognizing that it's possible to combine entertainment and science.

Hartmann: I think it's selling our souls.

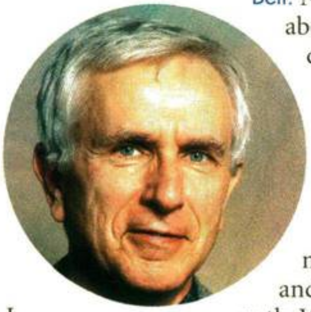
Chorus: [laughter]

Stern: We need to make science as approachable as possible, and if you want to call it entertainment, all the better, because I want to see the science done.

Porco: It's not a matter of really letting the public dictate what science we do; it's really a matter of explaining why the science we're doing is exciting and inviting them along on the journey, keeping them up to date on things. It's not the selling of the soul. It's the exercising of the imagination.

Grinspoon: If we remain an elitist enterprise then there's a limit to how much support we can get or even how much we deserve. But if we start thinking of it as potentially as exciting as any Hollywood blockbuster, or I would maintain even more exciting, and think of the budgets that go into that sector of society, then a lot more could potentially be accomplished.

Hartmann: It's a fact that this summer the Mars Global Surveyor team was ordered to redirect manpower to photograph the "face on Mars." Now the image was going to come



Bottom left: **William K. Hartmann of the Planetary Science Institute.**

Below left: **The Massachusetts Institute of Technology's Heidi Hammel.**

Right: Imke de Pater suggests the true nature of the Kuiper belt will be revealed in the coming years. "[Currently] we have no idea what's out there," she cautions. "Theorists disagree." **Below right:** NASA's Carl Pilcher. **Bottom right:** Carolyn Porco of the University of Arizona.

anyway in a few months because the orbit was evolving, but we were all excited about getting those pictures, and we targeted those pictures and were going to get them. But then NASA headquarters said, "We're getting too much flak from the tabloids, you guys have to do this right now," and our whole outfit, which was already understaffed, had to stop and figure out how to do that.

Porco: I think in that particular case the pendulum, momentarily and I hope temporarily, swung in the wrong direction. I think the handling of that particular issue was done by NASA (excuse me Carl) terribly wrongly. They never should have directed the principal investigator to do that.

Stern: Well, I'm definitely in the minority on this issue, and I've said this ten years ago, and I'll say it now. We are empirically, as far as the people who are paying the bills are concerned, in the entertainment business. We're not out there making the same kind of contribution as someone who's building a better bridge or designing a better aircraft. We're enlightening people's lives and providing something larger than life, just like, in a sense, professional sports or other entertainment.

Hammel: But you know, I don't think it's entertainment. It's right to say "something larger than life." They look to astronomers for that.

Grinspoon: Why differentiate? Really good entertainment is also philosophically inspiring. Look at the movie *2001*. I think it's really cool that we looked at the face on Mars, and I think the problem is with those PR people who wrote the wrong kind of press release about it.

Porco: In the routine exploration of the surface the camera would eventually have come over this area and would have photographed this region, and the scientists would have come forward and said, "By the way, here's the face on Mars." The revelation would have been the same, but the process would have been more logical.

Stern: Big deal. Life's messy. So we got asked to hurry it up.

THE KUIPER BELT

Astronomy: What will we know about the structure of the Kuiper belt in 25 years?

de Pater: One of the most promising activities is the Taos Project, to be run by Charles Alcock at Livermore, in which we will look for comets occulting stars. By doing that we can find bodies as small as a few kilometers in size, and therefore constrain the small end of the Kuiper belt objects. When you look at estimates of how many of these bodies we think there are and compare it with how many we detect, we may detect zero, or we may find thousands. We have no idea what's out there. Theorists don't agree. There really is no good estimate for how many small bodies — kilometer sized — exist out there and, also, how far out the belt goes. Right now we think the belt extends out to 50 AU, but with this technique we may be able to go much farther out.

Stern: I think Kuiper belt research will go a long way in the next 25 years. I think we'll find the propensity of planetary formation was much greater than we were all led to believe. I would not be surprised at all to find Earth-mass class objects that were ejected from the giant planet region. There's pretty good smoking-gun evidence that they were there. And surveys are getting to be not only very good, but very deep and complete. These objects can run, but they can't hide, and we may find them over the next 25 years. It's phenomenal.

Hammel: I think over the next 5 to 10 years the numbers of objects that we know of are just going to be exploding. Currently we know of 60 or something, well I know some people who are doing surveys in which they think they'll find 150 at a shot. You're talking 5 or 10 years from now knowing of thousands or tens of thousands, and that's fundamentally going to change the way we think about the solar system.

Stern: We always think of four terrestrial planets, four giant planets, and this little spit of a thing [Pluto], and what we're going to find is it's probably the first representative of the most populous class of planets in the solar system.

Hartmann: If you call them planets.

Chorus: [laughter]

IS PLUTO A PLANET?

Astronomy: How many people think Pluto is a planet?

Hammel: Are you going to define planet for us?

Stern: Pluto's two planets.

Chorus: [laughter]

Porco: It's two, it's two, it's two mints in one.

Chorus: [laughter]

Pilcher: When this thing first surfaced, there were letters that came in from schoolchildren all over the country that read, "Please, please, don't change Pluto from being a planet!" This is really counterproductive.

Porco: Brian Marsden wants to give it an asteroid number.

COMETS

Astronomy: What will we know about comets that we don't know now?

Grinspoon: We have several missions that will go to comets in the next few years, and we'll have in situ measurements of their compositions, their isotopic ratios; we'll know a lot more about comets and how they relate to the formation of planets.

Astronomy: We'll have a sample.

Chorus: Yes.

Meech: One of the big jumps will be from the present pairing of discoveries and colorimetry (studying sunlight scattered off the objects) to colorimetry and spectra because there are these taxonomic types of small bodies. So if we can begin to identify and tie in the Kuiper belt and Centaur populations of asteroids to existing populations we know more about, we'll begin to be able to understand where they came from.

Bell: We talked about sample returns. Every day we get 150 tons of samples. There's a huge meteorite collection out there. These small body missions, such as NEAR, which starts in January orbiting this small object, and others, are going to be the first link between separate meteorite communities that are studied in great detail; geochemistry of the early solar system is really what they're doing.

Hartmann: In that context, isn't it still the paradigm that most of the meteoritic sample stuff that we have does not seem to be coming from the inner belt and mid belt?

Bell: Well, that's what I thought when I came to this meeting, but I heard a talk that claimed it's more chaotic than that. Maybe we don't know where it comes from.

Hartmann: Do we have anything from the outer solar system or not? We know about Centaur objects, but we don't know whether we have any specimens in our museums from there.

Grinspoon: There's also the issue of comets and the origins of Earth's oceans. Recent isotopic measurements of three bright comets suggest that comets were not the source of Earth's oceans. If these three comets are typical, then Earth's oceans are made of less than 10 percent of water from comets. Which is fairly startling, but it may be that those comets are not representative of the kinds of comets that made Earth's oceans.

COSMIC DOOM

Astronomy: We mentioned the impact hazard to Earth. In 25 years will we have more people than the number staffing a McDonald's working on this question?

Stern: There may only be a

Left: Jim Bell reminds participants that not only will comet sample return missions give us some primordial solar system material, but every day 150 tons of solar system dust falls to Earth. "There's a huge meteorite collection out there," he says.
Above left: Alan Stern of the Southwest Research Institute.

McDonald's worth of people working on it, but they may be very effective.

Astronomy: Will there be enough funding for this in the future?

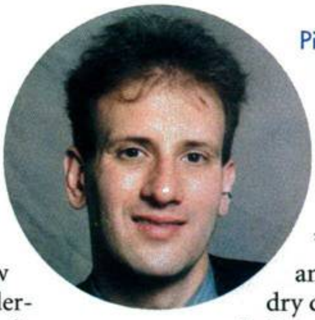
Pilcher: NASA is committed. We have committed to the Congress of the United States to pursue the Spaceguard survey goal, which is to catalog at least 90 percent of the objects larger than one kilometer in diameter in the next decade, and we're going to do what's necessary to do that.

THE FUTURE OF PLANETARY SCIENCE

Malhotra: Planetary science may be a misnomer. It's really planetary exploration.

Pilcher: I'll say that probably not in 25 years but in 100 years the nature of planetary science will become the tradition of science. We'll see more of exploring the relationships between the traditional disciplines. The boundaries between those disciplines are going to break down.

Porco: I think we stand at a juncture right now. It's hard to know where to draw the line, but we've completed the age of exploration. There's still Pluto left unexplored, and I would add Titan, but we've nearly completed the renaissance of the planets. Now we stand poised at the threshold of a new age, an age of understanding, where we're really putting together all those things we've learned about other planets, comparing with Earth, and putting them into context. We're just embarking on this inquiry right now. Even from looking at what's happening at this particular DPS meeting, our presence seems to be everywhere. We have Mars Global Surveyor; we have NICMOS; we have HST; we have Galileo; we have people still looking at Voyager data; we have Cassini imminent; we're everywhere it seems. And think about the 1980s. The only thing going on was the Voyager mission. It's just going to be a data explosion. We're going to have daily reports of weather and seismicity from Mars. It's going to be very, very exciting, and different, very different.



Pilcher: We're launching a planetary mission every six weeks for 10 months.

Porco: And in the '80s we didn't do anything. That was the dry decade. There was only Voyager. There was a time when Voyager was the only thing going on.

Hammel: Remember the pictures of astronauts on the moon? Our dreams, as children, seeing a man on the moon, were that we'd be on the moon too and that we'd be in outer space, and we'd be zipping around the solar system. Then that all went away. But as a child I thought the space age would have gone a lot further than it really has. The political realities have changed all that. Will we go back? I would certainly hope so, for the sake of planetary science and for the sense of knowledge and spirit of humans at large. ■

Right: ***Astronomy's*** **managing editor Dave Eicher and associate editor Bob Naeye help face the panel of 10 planetary scientists opposite Wisconsin's capitol in Madison. Nearly the whole editorial staff participated in this unique event, which lasted three hours.** **Above right:** **David Grinspoon of the University of Colorado.**

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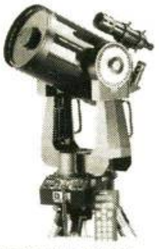

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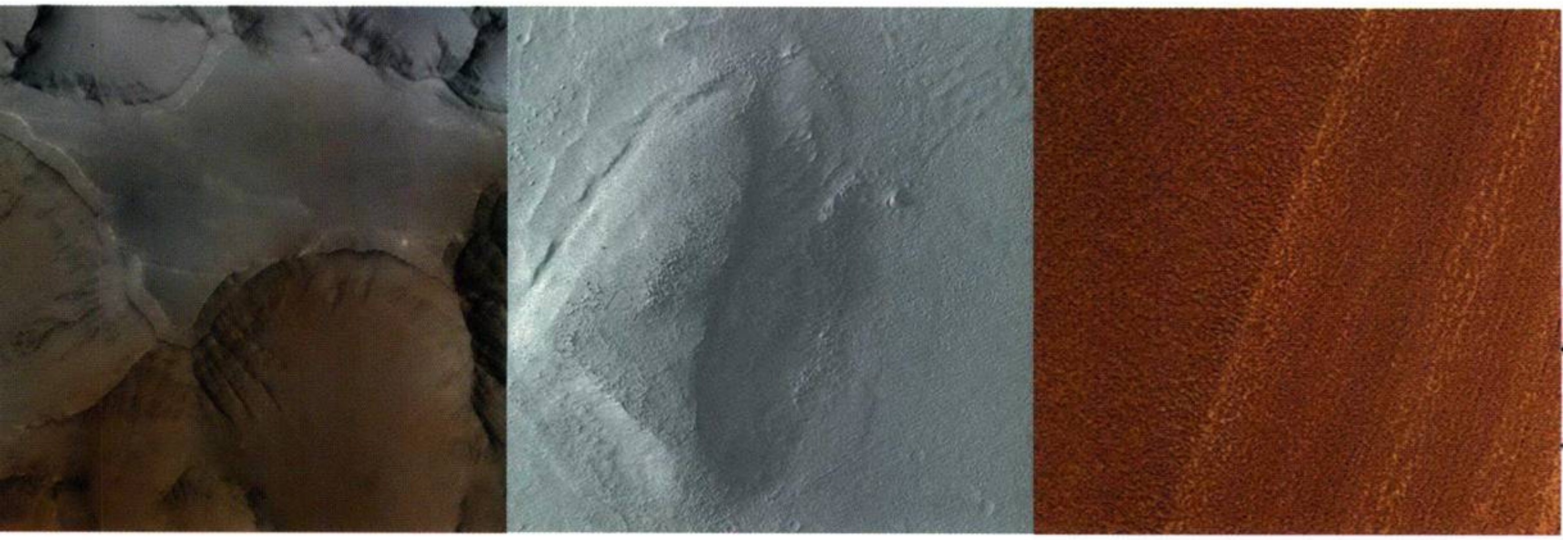


Left to right: An exposed rock face in Valles Marineris exhibits layers, which preserve a record of Mars's early geological history. Boulders rest atop a hill in the Utopia Planitia region. Layered deposits run along a slope near the northern polar ice cap. Wind erosion exposes an ancient, buried crater in Kasei Vallis. A localized dust storm obscures the surface above the Viking 1 landing site in Chryse Planitia.

United States Geological Survey

Mars Global Surveyor looks for clues to the origin of life.

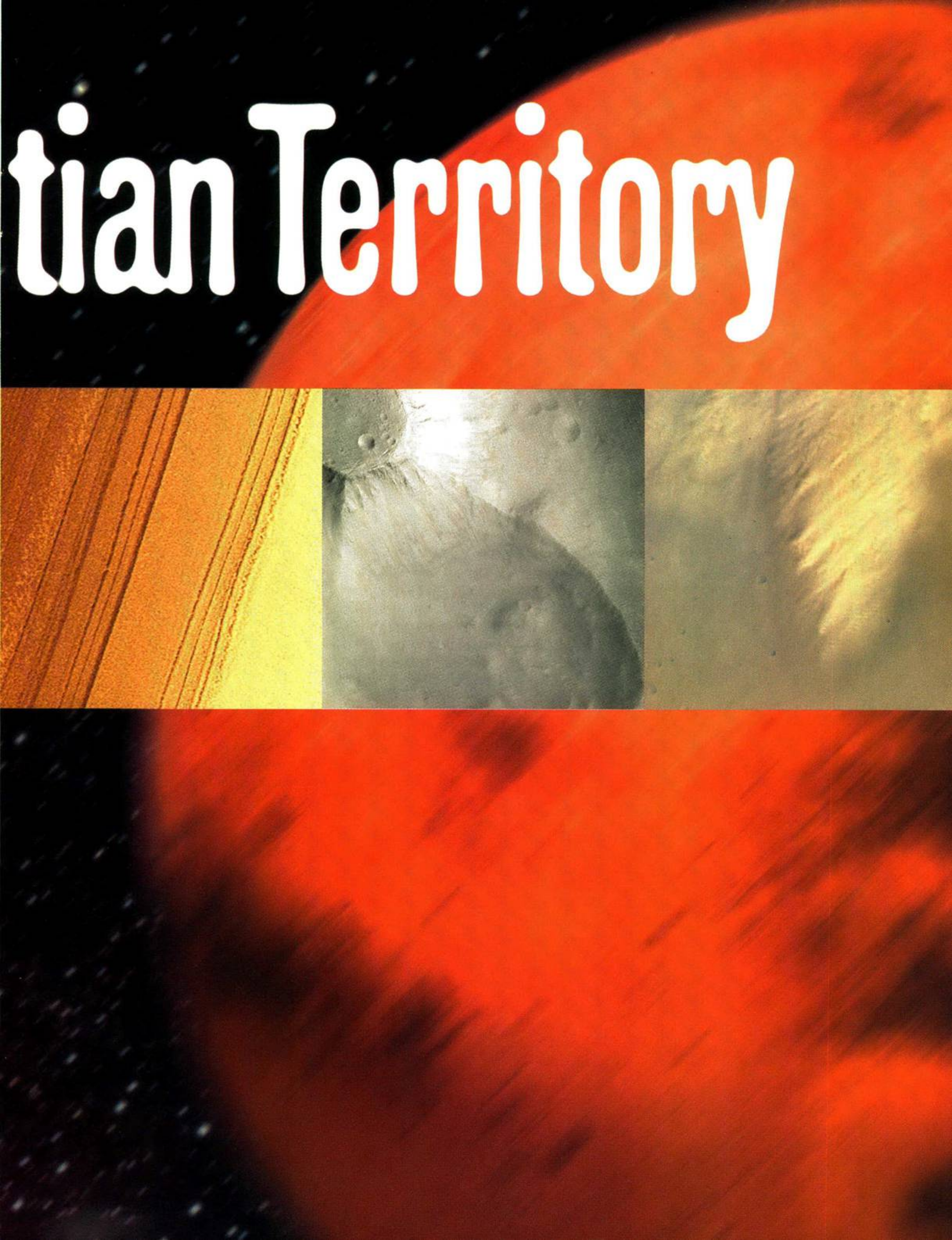
by William K. Hartmann

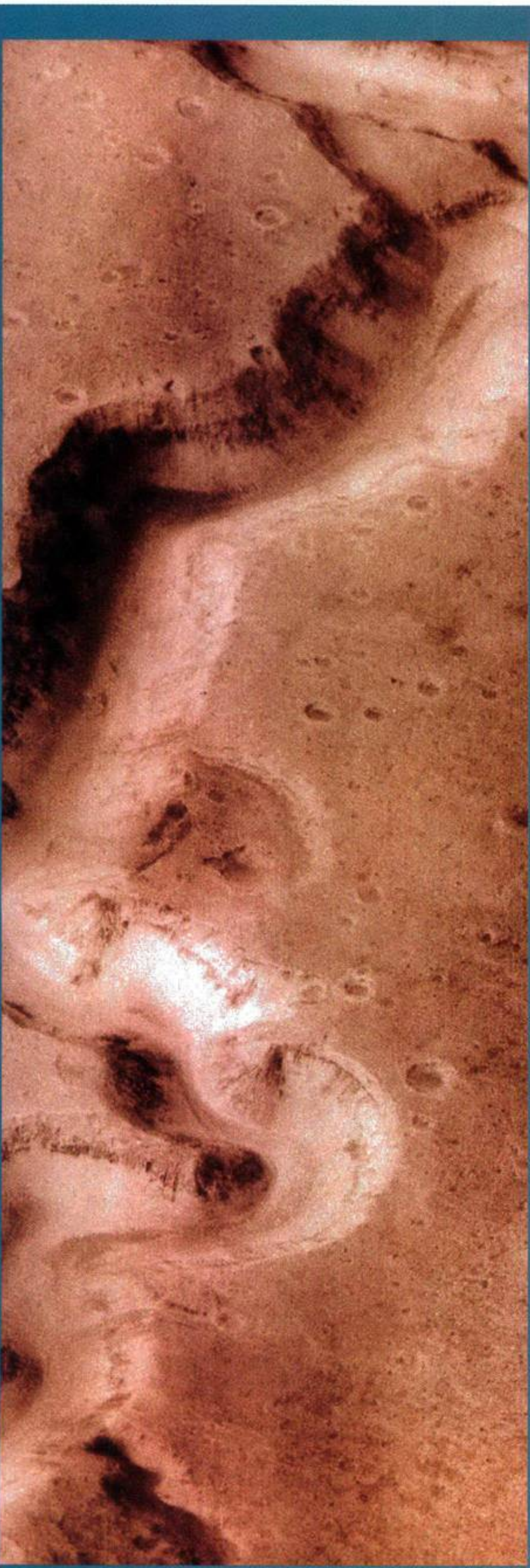
Of all the diverse worlds in the solar system, Mars has the most to tell us about our own relation to the cosmos. Mars reveals clues about how an earthlike planet evolved and about the conditions that can lead to the origin of life. And because Mars is a place where humans may someday live off the land, we need to know more about what that land is like.

In December 1996, NASA launched Mars Global Surveyor (MGS) — a sophisticated yet inexpensive orbiter — to learn more about past and present conditions on the Red Planet. In September 1997, when MGS entered Mars orbit, the planet was already known to harbor many mysteries: How did a now-dry, frozen world with huge extinct volcanoes get laced with ancient river channels? When were the rivers active? Was there ever enough water to make oceans or lakes? When and why did the water dry up? When did volcanism die?

Many researchers thought that volcanoes and riverbeds were fossil vestiges of a planet that had seen volcanism and liquid water on its surface only in its early days. Mars, in other words, might have had a thick atmosphere and geological activity for only the first billion years of its history. Other scientists think that the last vestiges of volcanism died out 2.5 billion years ago. In both views, the planet never had enough internal heat to power volcanoes for very long; the planet cooled off, the volcanoes died, the atmosphere dissipated into space, and the planet has been a cold dust bowl ever since.

tian Territory





Meandering Nanedi Vallis is only 1.6 miles (2.6 km) across. Oxbow features are indicative of flowing water. The narrow gully at the upper right suggests a secondary period of flowing water.

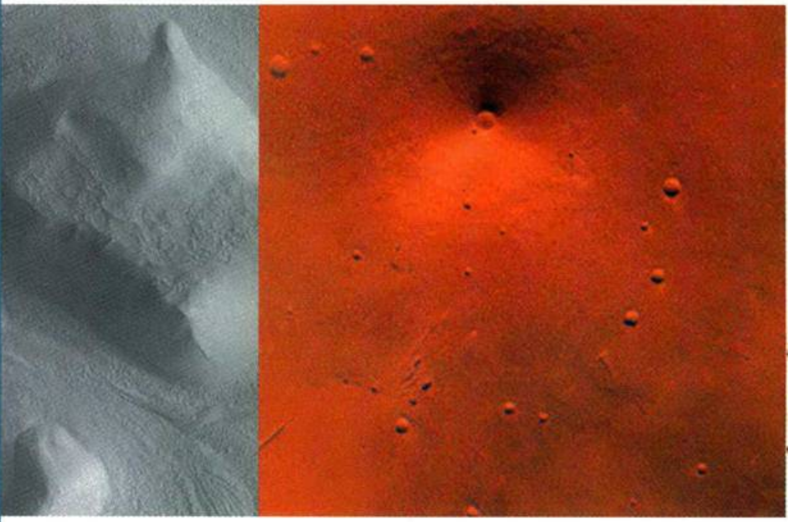
All images courtesy Malin Space Science Systems/NASA unless otherwise indicated

But after 18 months in orbit, MGS is painting a new picture of the Red Planet's history. The orbiter reveals a more complex and geologically active planet, where internal heating persisted for some time and where volcanoes may still be active today. The spacecraft has even yielded evidence that there may have been more than one episode of flowing water.

Candid Camera

All four of MGS's instruments have returned important information, but its telephoto camera has been the star of the show. The camera is essentially a 14-inch f/10 telescope designed by geologist and imaging team leader Michael Malin and was built at Malin's company, Malin Space Science Systems of San Diego, California. From martian orbit, the highest resolution pictures reveal features as small as a bus.

As of early December 1998, the camera had taken more than 1,000 images. One of the most striking pictures shows as many as 80 layers of rock strata — probably frozen lava — exposed in a cliff wall of Valles Marineris, a canyon nearly 3,000 miles (5,000 km) long. Other images of exposed rock faces in Valles Marineris show similar layering. At an October 1998 planetary science conference, Malin concluded that the camera's most significant revelation to date is the large extent of this layering and the hope it offers for well-preserved sequences of rock that date back to Mars's earliest history. Geologists may someday take their hammers and chisels and read these layers like a library book to learn about the vigorous erosion and deposition early in Mars's history.

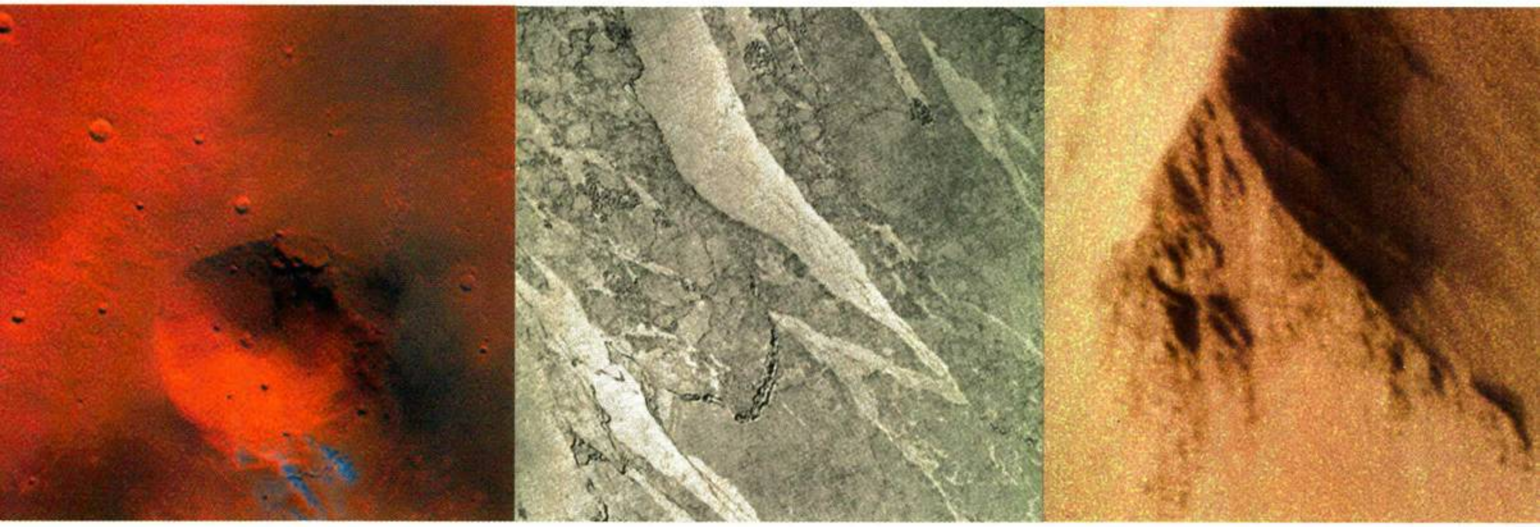


Center to right: Two giant volcanoes tower above the Elysium volcanic region: Elysium Mons (left) and Hecates Tholus (right). Giant slabs of frozen lava dominate the Elysium basin, located south of the towering Elysium volcanoes. An exposed rock face in Tithonium Chasma — a small section of Valles Marineris — reveals more than 80 layers.

Other images show terrain blanketed under layers of sediments. One dramatic image shows an impact crater in Kasei Vallis sticking out from under a 3,000-foot cliff. The impactor smashed into Mars billions of years ago, and the resulting crater was later covered under at least a mile of windblown or water-borne dusty sediments. Eventually, wind erosion swept away the material, exhuming the ancient, underlying crater. If ancient surfaces are buried and then sometimes re-exposed, future spacecraft may be able to find areas on Mars where ancient deposits are exposed, possibly even deposits formed in lakes.

Scientists are also interested in young surfaces. Imaging team member Alfred McEwen of the U.S. Geological Survey has presented MGS images of the Elysium basin: a flat, sparsely cratered region with puzzling textures that lies south of the giant volcano Elysium Mons. From photos taken by the Viking orbiters in the 1970s, scientists suspected the Elysium basin to be a young, volcanic plain. The MGS photos confirm this view. They show what appears to have been a vast lava lake in which plates of lava cooled and jostled against one another as they solidified. The near-absence of even small impact craters, which are abundant elsewhere on Mars, suggests that the lava flows are very young.

This finding agrees with my own research as an imaging team member. I have worked with planetary science students in Madrid, Spain, and Arizona to compile crater statistics for young martian volcanoes and lava plains such as Amazonis Planitia. We found that these surfaces have only a few percent as many impact craters, at all diameters, as the moon. For any plausible impact rate on Mars, these numbers suggest that Amazonis Planitia and other young martian surfaces are no more than a few hundred million years old. In that case, the Elysium lava flows, with their still lower numbers of impact craters, would have to be even younger. If correct, it means that volcanism did not die out billions of years ago as many scientists had thought but is essentially an ongoing process on Mars.



MGS images of dry riverbed channels provide some of the best clues about the history of running water on Mars. A high-resolution image of one of these channels, Nanedi Vallis, provides several hints that running water was not confined to a single early epoch. The image shows several different terraces cut by the channel. Initially the river flowed along one course, but then it shifted, leaving old terraces and almost cutting off some loops, like the detached "oxbow" lakes along the winding Mississippi River. On Earth, such meanderings are typical of rivers that have flowed for a long time and built up fairly level flood plains. In addition, in the middle of the large, worn-down channel, the MGS image shows a narrow, sharp gully. It looks suspiciously like it was formed later than the main channel. If so, the riverbed was not formed in one single burst of activity but had episodes of flow, followed by dry spells and more flows.

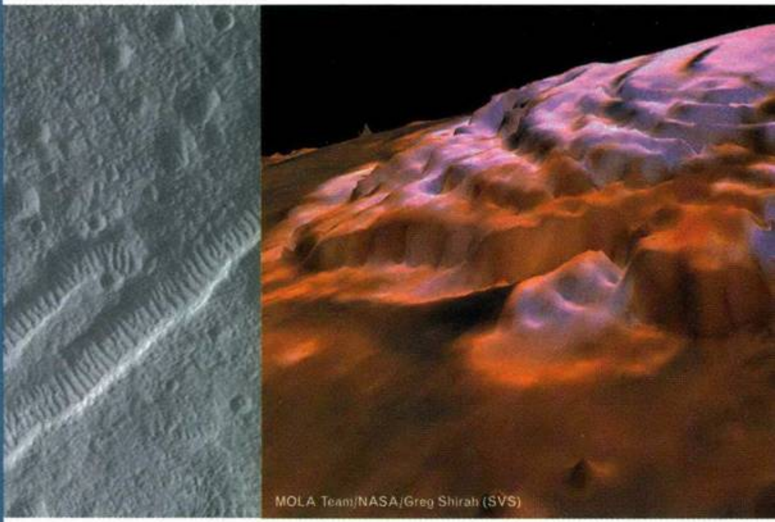
If there were several episodes of water flow, were they one month apart or 100 million years apart? Most geologists suspect that it would take a long period of flow, not just one catastrophic event, to cut this channel into the desert. But there is no proof. Such pictures keep alive the suspicion that Mars has seen extended cycles of clement conditions with water flow, followed by cold, dry, desert conditions — possibly like Earth's alternation of ice ages and clement periods — rather than a *single* ancient watery episode at the beginning. The mystery might not be solved until we obtain samples from selected sites on Mars's surface.

Mars's Magnetic Personality

Throughout the orbiter's first year of operation, all the instruments performed flawlessly, although not quite in the manner for which they were designed. When MGS arrived at Mars, it entered a highly elongated elliptical orbit. Flight controllers at NASA's Jet Propulsion Laboratory originally planned to fine-tune the orbit by periodically dipping the spacecraft into Mars's upper atmosphere, a technique called aerobraking. The friction with the atmosphere, like the force you feel when you stick your hand out the window of a moving car, would slow the spacecraft into a 250-mile-high (400 km) circular mapping orbit by March 1998. Unfortunately, one of the two solar panels didn't deploy quite fully. To reduce stress on this panel, flight controllers had to cut back the pace of aerobraking so that the final circular mapping orbit would not be attained until March 1999. Thus, all data in 1998 had to be taken from a more elongated orbit, at both higher and lower altitudes than expected.

For MGS's magnetometer, the one-year delay proved to be a blessing in disguise. Because the elongated orbit carried the spacecraft below the martian ionosphere for longer periods than planned, the magnetometer could pick up magnetic "signals" close to the planet. Today, Mars's magnetic field is so weak that a compass would barely work. But to everyone's surprise, the magnetometer measured a dozen or more local patches, tens of miles across, with relatively strong magnetism and differing orientations. If MGS had followed its planned course, charged particles in the ionosphere would have prevented the magnetometer from picking up these signals.

The magnetometer team, led by Mario Acuña of NASA's Goddard Space Flight Center, is excited by this result because these magnetic anomalies probably represent old lava flows that formed billions of years ago when Mars had a strong magnetic field. In molten lava, iron minerals act like tiny compasses that align with whatever magnetic field happens to be present at the time. If ancient lavas cooled into rock when the planet had a strong magnetic field, then the iron minerals would have "frozen in" the configuration of the existing field. Because a planet's magnetic field is created by currents in a molten iron core, this suggests that the core stayed molten until after the period of heavy asteroid bombardment ended 3.8 billion years ago, although the conditions in the core necessary to create a full-fledged magnetic field may have existed only in ancient times. The existence of a strong magnetic field billions of years ago could play a role in scientific debates about life on Mars because the field may have protected the surface and atmosphere from solar wind and cosmic ray interactions.



MOLA Team/NASA/Greg Shirah (SVS)

Center to right: Based on data from Mars Global Surveyor's altimeter, scientists constructed this vertically exaggerated relief map of Mars's north pole. This small volcano in the Tempe Terra region has a 1.2-mile-long elongated caldera; an impact crater is at the lower left. The dark deposits on the floor of this 30-mile-wide unnamed impact crater may contain minerals that formed in liquid water.

An Ancient Ocean?

MGS's altimeter is vastly improving our understanding of martian topography because it can measure altitudes on Mars to an accuracy better than a meter. The team, led by David E. Smith of NASA's Goddard Space Flight Center and Maria Zuber of MIT, hopes to improve the global network of altimetry so that we know whether certain features are higher than nearby features. But we also want to know the absolute altitudes of volcanoes and other features relative to a planet-wide reference level (like sea level on Earth).

The altimeter has found that the topographic profile from the southern highlands down into the northern plains resembles the profile from terrestrial continents into smooth, sediment-covered sea floors. The northern plains themselves are extraordinarily flat, leading to quips that they represent the solar system's largest pool tables. Furthermore, "benches" around the edges of some of these plains are turning out to have uniform elevations, like beach deposits left at sea level

MGS in SF

For centuries, scientists wondered about the origin of Mars's dark markings, which can be seen through small amateur telescopes near opposition (see "Red Planet at Night, Observer's Delight," page 88). Until the Space Age, some prominent scientists thought these dark markings might be primitive vegetation. Spacecraft later showed them to be windblown dust. But why were some dust-covered regions bright and others dark?

At the December meeting of the American Geophysical Union in San Francisco, Wendy Calvin of the U.S. Geological Survey offered a fresh perspective on this age-old problem. She noted that many dark markings are concentrated in areas where old water-carved channels appear. She argued that these dark markings relate to iron sulfide stains on rocks that were formed by reactions involving hydrogen-sulfide-bearing water.

At the same conference, MGS imaging team member Michael Carr of the USGS argued that the channels were mostly formed by seepage of underground water — perhaps geothermally melted permafrost. Thus, the newest work implies that to understand the secrets of Mars, we have to understand the role of underground water and ice.

If Carr is correct, there may have been a great deal of water percolating underground on early Mars, and this water may even have been geothermally heated. Because genetic evidence indicates that Earth's microbial life may have begun in geothermally heated ponds, this suggests that the conditions for the origin of life existed on early Mars.

—W. K. H.

on Earth. This strengthens arguments that Mars's northern plains may actually be floors of ancient seas or oceans — a hypothesis that remains controversial.

At the December 1998 meeting of the American Geophysical Meeting in San Francisco, the altimetry team announced results from the north polar region. From altimetry profiles of the top surface of the northern ice cap and the contours of the surrounding land surface, the team could estimate the volume of frozen water in the cap. The north cap has roughly half the ice of Greenland's ice cover — a smaller amount than many previous estimates. This suggests that the ice caps can't contain enough water to fill hypothetical ancient martian oceans. The ice caps, however, might contain only a small fraction of the total subsurface ice and water on Mars, in the form of buried permafrost and subsurface aquifers.

This returns us to the question of whether there was ever enough water at any one time to create lakes and seas in the low-lying areas — a $64,000 question when it comes to speculating about the origins of life. The orbiter's Thermal Emission Spectrometer offers a way to solve that mystery. If water ran across the surface, certain minerals, including carbonates, sulfides, and salts, would have dissolved in the water. As mineral-rich water collects in ponds or lakes and evaporates, these minerals are concentrated in the remaining water, as in Utah's Great Salt Lake. When the water completely evaporates, these "evaporite" minerals are left behind. Evaporite minerals are common in dry lakebed deposits on Earth, where the soils are often white and actually taste salty. If MGS can find such deposits on Mars, they would be smoking guns that ancient Mars had lakes or seas.

Because it can detect evaporites, MGS's spectrometer is in some respects the spacecraft's most important instrument. It detects the infrared radiation emitted by Mars itself, not the energy of reflected sunlight. Different minerals have different spectra, so the idea is to look at different regions and measure their compositions. The spectrometer can measure compositions of patches about 2 miles (3 km) across.

Although the instrument worked perfectly throughout 1998, Phil Christensen of Arizona State University and his team were frustrated because there were large quantities of dust and ice clouds in Mars's atmosphere. Many spectra showed primarily airborne dust — which consists of a mix of debris eroded from all over Mars. These spectra gave merely a generalized indication of volcanic rocks, which is nothing new. Researchers hope that measurements can be made under clearer atmospheric conditions in 1999.

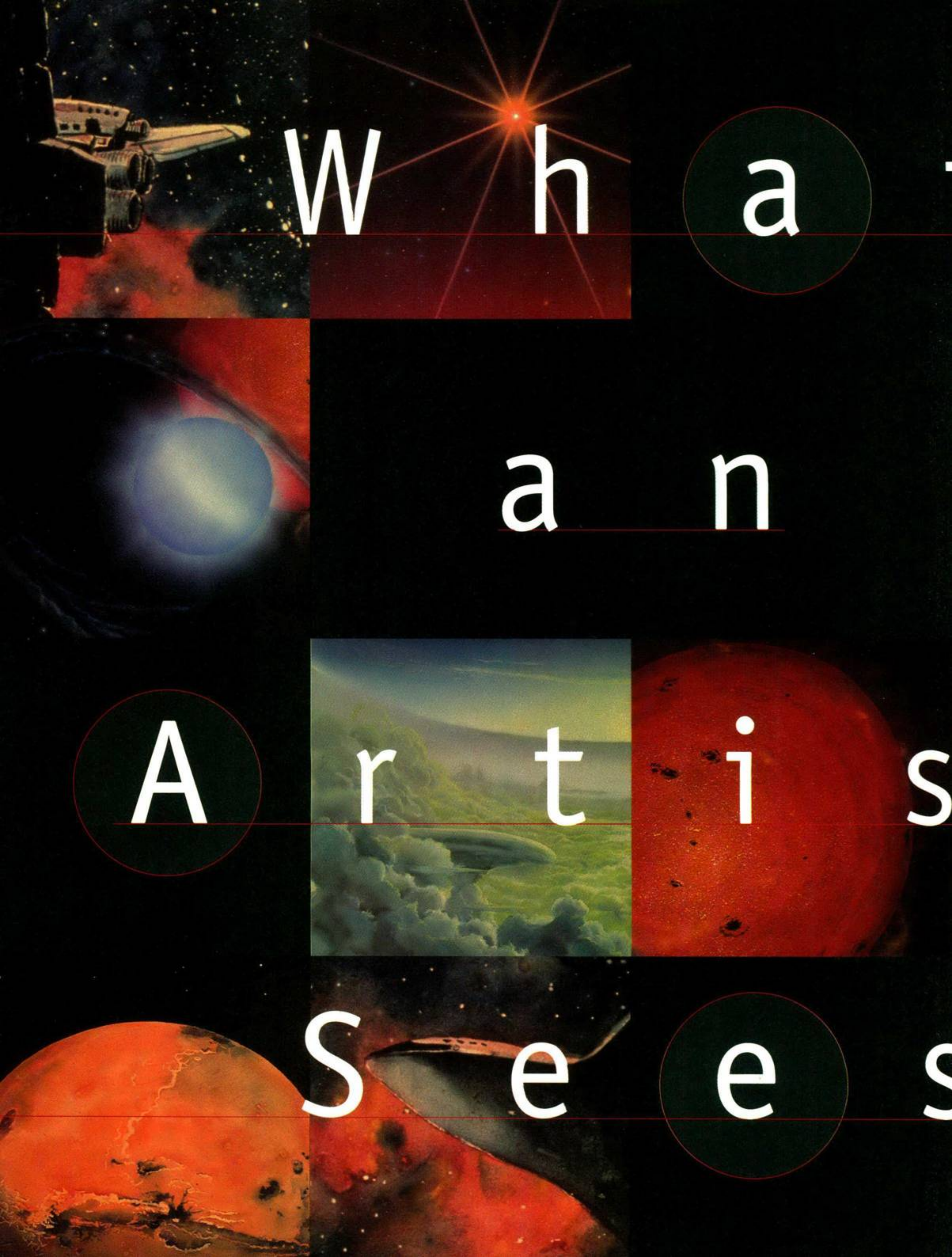
Despite the difficulties, the spectrometer has delivered at least one major result. It located a deposit rich in coarse-grained hematite, an iron oxide mineral, on the equator near 0° longitude. This deposit was probably left by geothermally heated water that dissolved iron minerals before evaporating. So far, no massive deposits of evaporites have been found, but there are hints of sulfide-rich soil and perhaps localized carbonates in some regions — which may be an indication of evaporites and ancient lakes. This work is continuing.

Blazing a Trail

As Mars Global Surveyor enters its circular mapping orbit, scientists hope it clarifies the extent of recent volcanism and the strength of the ancient magnetic field. Because the camera and spectrometer were specifically designed to work from the mapping orbit, they will be better able to search the whole planet for tell-tale signs of ancient lake-bed or seafloor deposits and answer the question of whether the planet once had the kind of environment that could have harbored microbial life.

MGS's results will pave the way for near-future exploration of the Red Planet as well. Scientists will use images taken this spring and summer to select Mars Polar Lander's landing site (see "Divining on Mars," February 1999). Results from MGS will be crucial in finalizing plans for future NASA landers and even a sample-return mission. One or more of these landers may touch down in low spots where water may have ponded, in the hope that soil-analysis instruments can measure actual sediments deposited on the floors of ancient martian lakes. Mars Global Surveyor is not only exposing the martian past, it is also charting new pathways toward future Mars exploration.

William K. Hartmann, a senior scientist at the Planetary Science Institute in Tucson, Arizona, is a member of the Mars Global Surveyor imaging team. He was recently awarded the Carl Sagan Medal for his skills in communicating planetary science to the general public. He was one of the panelists in Astronomy's *planetary science forum (page 36).*



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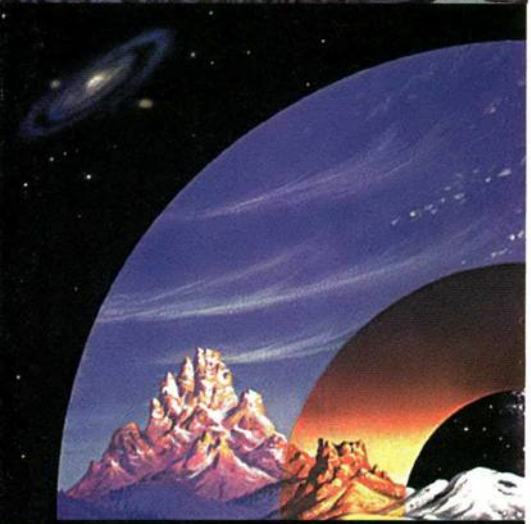

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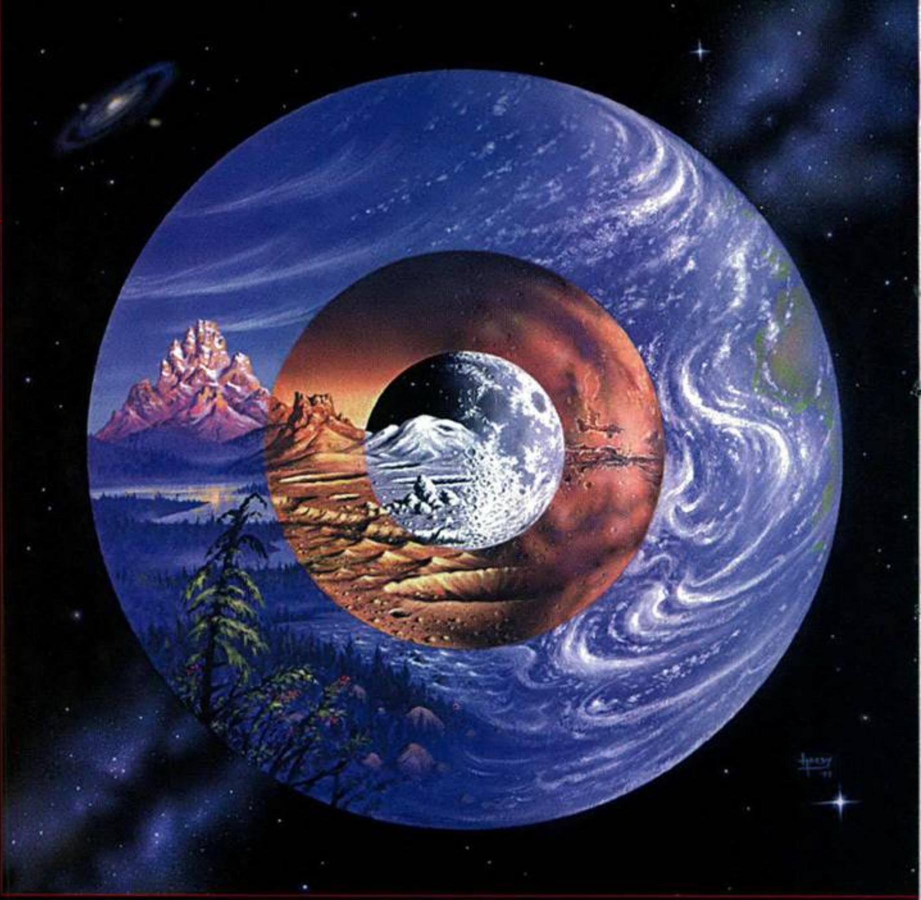
More than 25 years ago, *Astronomy* was born with a desire to be the most beautiful science magazine in the universe. One of the editors' goals was to publish works of the best space artists and their concepts of how planets, stars, and other astronomical objects might look. Since 1973, science has been making us more familiar with the planets and stars than we might have guessed we would ever be. Astronomical discovery has stretched the limits of the universe. The Hubble Space Telescope alone has shot more than 140,000 photographs of our solar system and far beyond. We know many more details about our universe now, and we have captured intimate versions of everything from our moon to the deep field galaxies. Our pages are filled with the fruits of ongoing research and the undeniably beautiful images from space science missions. Because of this, we no longer carry artists' concepts on every page. Still there is plenty that we can't see. Who but an artist could show us a black hole or an extrasolar planet? While space art is still critical to our publication, it is no longer prolific, and we had begun to miss it. To remedy that, we decided to present a collection of fine images for their own sake, a space art gallery. We invited members of the International Association of Astronomical Artists (IAAA), a 133-member organization begun in 1982, to provide us with images. The IAAA leadership liked the idea and put out a call by Internet and newsletter. The submissions began to pour in. The organization created a private website where the art was displayed. Each of seven board members selected 10 favorite images, and then in another round of computer voting, the 70 finalists were whittled down to 20. According to IAAA president David Hardy, the board members looked for space art based on an "informed knowledge of the universe." The editors and art director of *Astronomy* narrowed the selections to seven. For more information about the artists, visit the IAAA Website at http://www.IAAA.org/. We hope you enjoy our gallery. — *Bonnie Gordon*



Neighbours

BY DAVID A. HARDY

This 36 by 36-inch acrylic on canvas was painted in 1997. Its subject is Earth and two of its neighbors, Mars and the moon, which are shown to scale. In the background appear the Milky Way Galaxy and its neighbor, the Andromeda Galaxy.

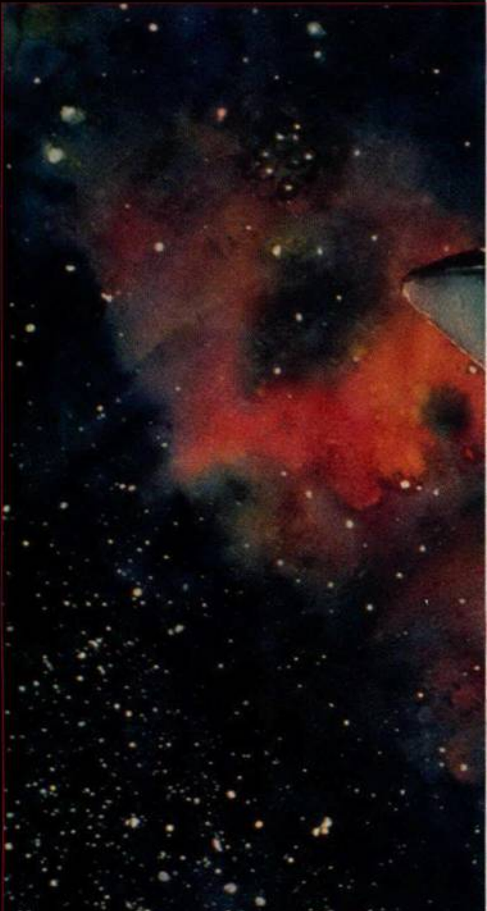
Hardy's work was first published in 1952, when he was 16. Only the Russian cosmonaut Alexei Leonov and the Japanese artist Kasuaki Iwasaki have been working in the field for as long as Hardy. He is currently president of the IAAA and has a website at http://www.hardyart.demon.co.uk. He has worked on many books with British astronomer Patrick Moore and with Carl Sagan and has written and illustrated seven of his own books.

Across the Sea of Stars

BY APRIL FAIRES

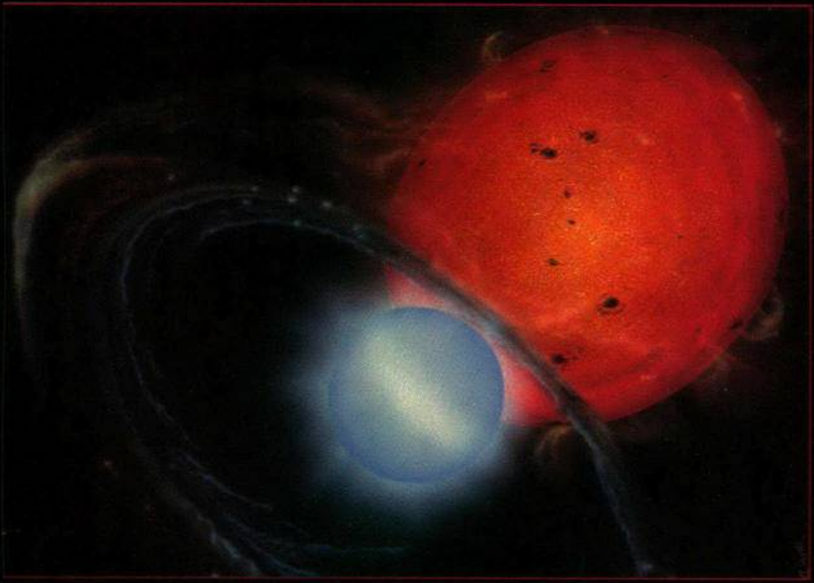
Faires painted this 16 by 22-inch watercolor while working on an Earth Science/Art Education degree at Eastern Washington University. The inspiration came to her after going onboard the full-scale training shuttle at Johnson Space Center during an IAAA hardware workshop in 1987.

Faires has been an artist since she was old enough to hold a pencil. She took up space art during her first year at Washington State University but has been interested in astronomy since her early teens. In addition to space art, Faires specializes in birds, botany, and landscapes. A graphic designer at a nonprofit purchasing cooperative for Washington state, Faires works in watercolors, colored pencil, and silverpoint.



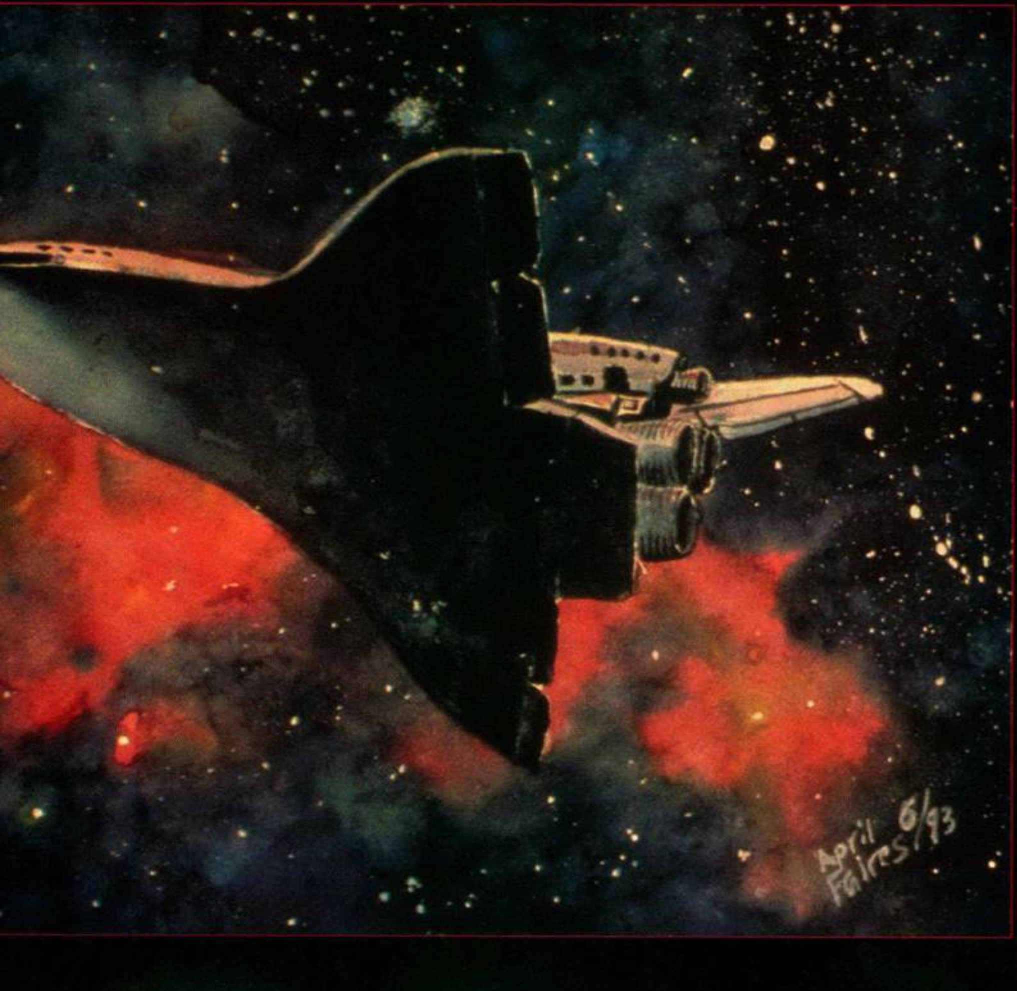
Nova

BY MICHAEL CARROLL



This 16 by 20-inch acrylic painting was made using airbrush and conventional brush. It originally was done for Robert Naeye's book, *Through the Eyes of Hubble*. The view shows gas from a red dwarf star spilling onto a white dwarf companion to form a barely glowing disk around the white dwarf. As debris falls onto the equator of the star it glows more brightly.

Michael Carroll's words and space paintings have appeared in the pages of *Astronomy* for many years. His work also appears in *Time*, *Smithsonian*, *Popular Science*, and many other magazines and books. Formerly a staff artist for the Reuben Fleet Space Theater and for OMNIMAX theaters in San Diego, he now lives in Denver.

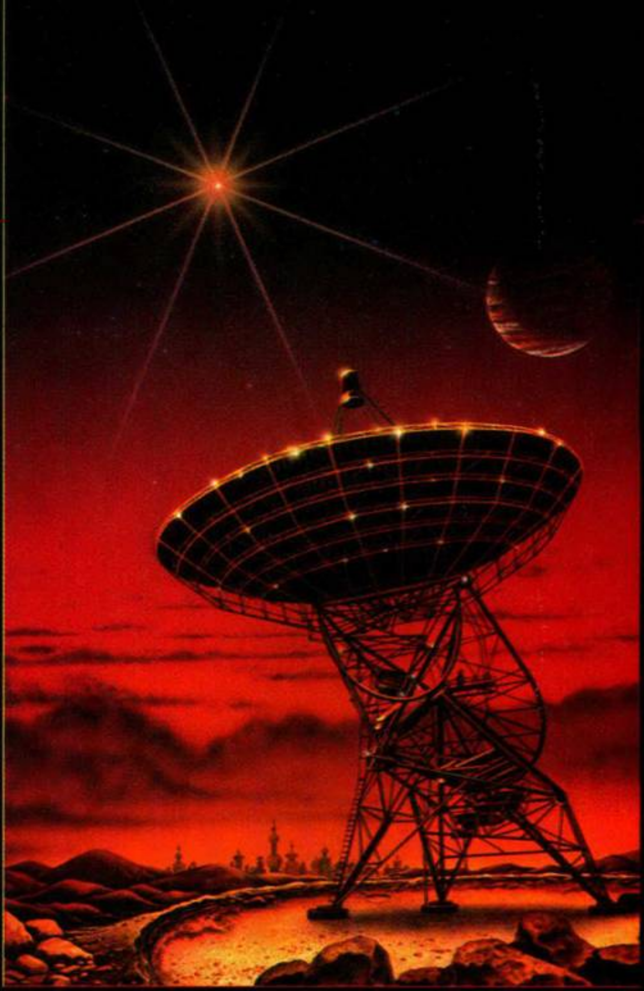


Legacy

BY LYNETTE COOK

Cook's painting depicts a future era of space travel and colonization, when humankind has settled on the satellite of a Jupiter-like planet. The moon has an atmosphere similar to Earth's; therefore, the sunset glows crimson. A city can be seen in the distance. A large radio telescope has been constructed on the floor of a shallow crater. Lynette's original painting is mixed media: a combination of acrylic, gouache, and colored pencil.

Cook double majored in biology and drawing and painting at the Mississippi University for Women, after which she moved West to attend the California College of Arts & Crafts, specializing in scientific illustration. Since 1984, she has worked as an artist/photographer on the staff of the Morrison Planetarium at the California Academy of Sciences in San Francisco and maintained a healthy freelance career, illustrating natural science subjects for such clients as Houghton Mifflin, Random House, *Reader's Digest*, Time-Life Books, *Astronomy*, *Fine Cooking*, *Omni*, and *RN*.

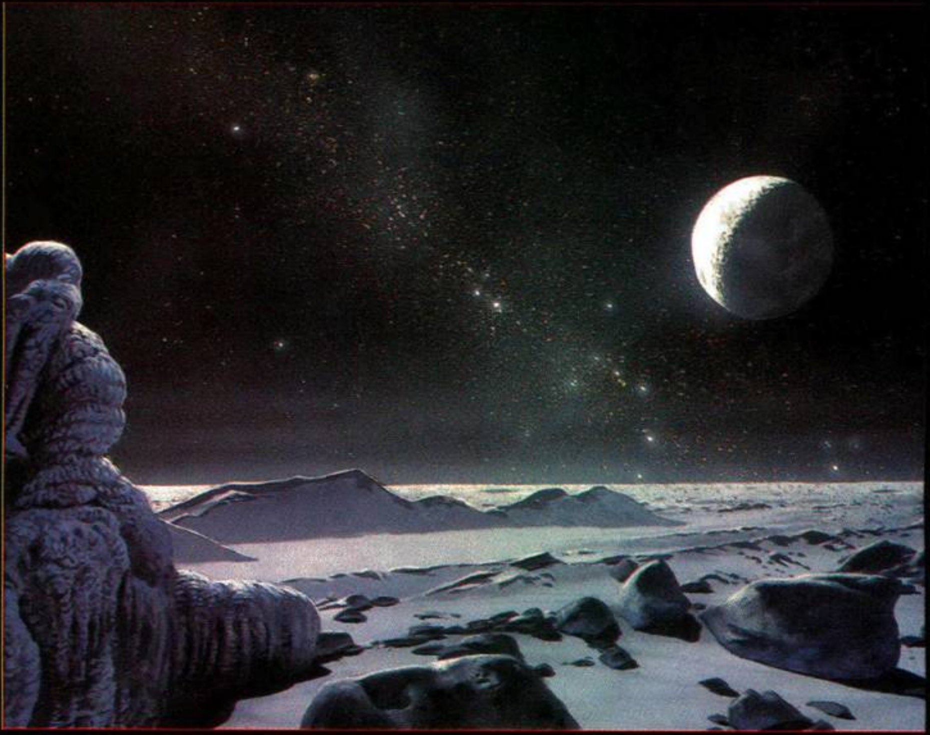


Pluto Panorama

BY RON MILLER

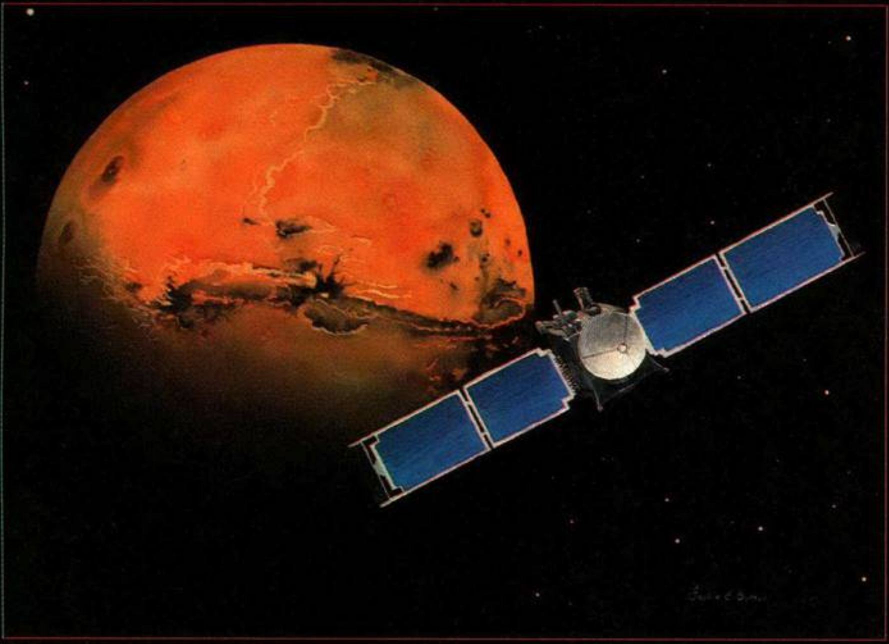
This 15 by 20-inch acrylic was painted on illustration board. It was one of 25 Miller painted for a new edition of a book he co-authored with William K. Hartmann, *The Grand Tour*. Like almost all of Miller's astronomical artwork, this one has two purposes: It is his way of visiting other planets, and he hopes to convey to a popular audience the reality of space. He wants viewers to know about these worlds and their terrain and landscape.

Miller, who lives in Virginia, has made thousands of images of space and spaceships. He specializes in science fiction, science, and fantasy and has authored or edited more than 20 books. Miller has illustrated the books of other authors and many magazine articles. He worked as a production illustrator on a number of films, including *Dune* and *Total Recall*.



Surveyor 1

BY JACKIE E. BURNS

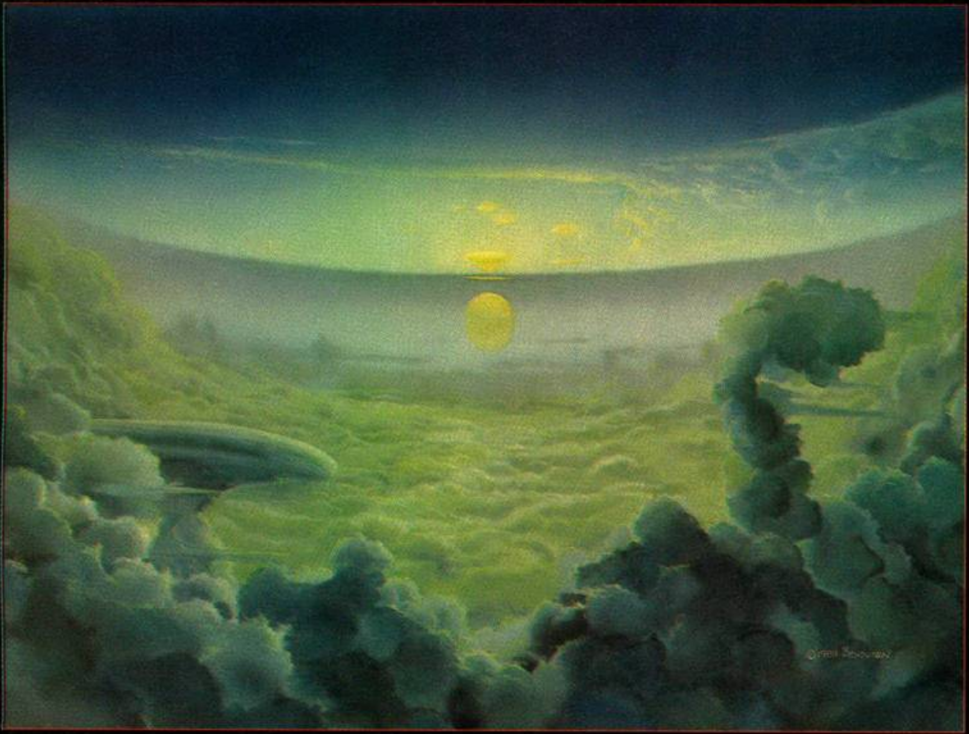


This 14 by 21-inch painting of Mars Global Surveyor's arrival at the Red Planet is worked with Croma Artists Color by hand; Burns usually paints with an airbrush. She used liquid masking and wet-on-wet to build up the texture of the planetary surface. "This was a risky but fun way of allowing the colors to indicate the depth and perspective of the Valles Marineris canyonlands and the channel systems that trend north of the planet," she says. The satellite is depicted without its protective foil blanket to highlight detail.

British artist Burns, vice president of IAAA, specializes in airbrushed and digital artwork of contemporary and conceptual astronomical images. Her work is featured in several international collections. She is currently advising the Science Centre at Jodrell Bank, Chester, U.K., on its new permanent art gallery.

Sunset from Neptune's Great Dark Spot

BY SALLY J. BENSUSEN



This painting shows the setting sun viewed from just below Neptune's methane cloud deck in its upper atmosphere. Methane is unusually refractive, and the way its density varies with altitude would allow a viewer floating below the cloud deck to witness the appearance of multiple suns.

Formerly an astronomer and computer programmer with Goddard Space Flight Center and the U.S. Naval Observatory, Bensusen became a full-time scientific illustrator in 1981. Her work appears in *Smithsonian*, *National Geographic Traveler*, and *Scientific American*. She produced a mural for the National Aquarium and paintings for Hayden Planetarium.

comet STALKER

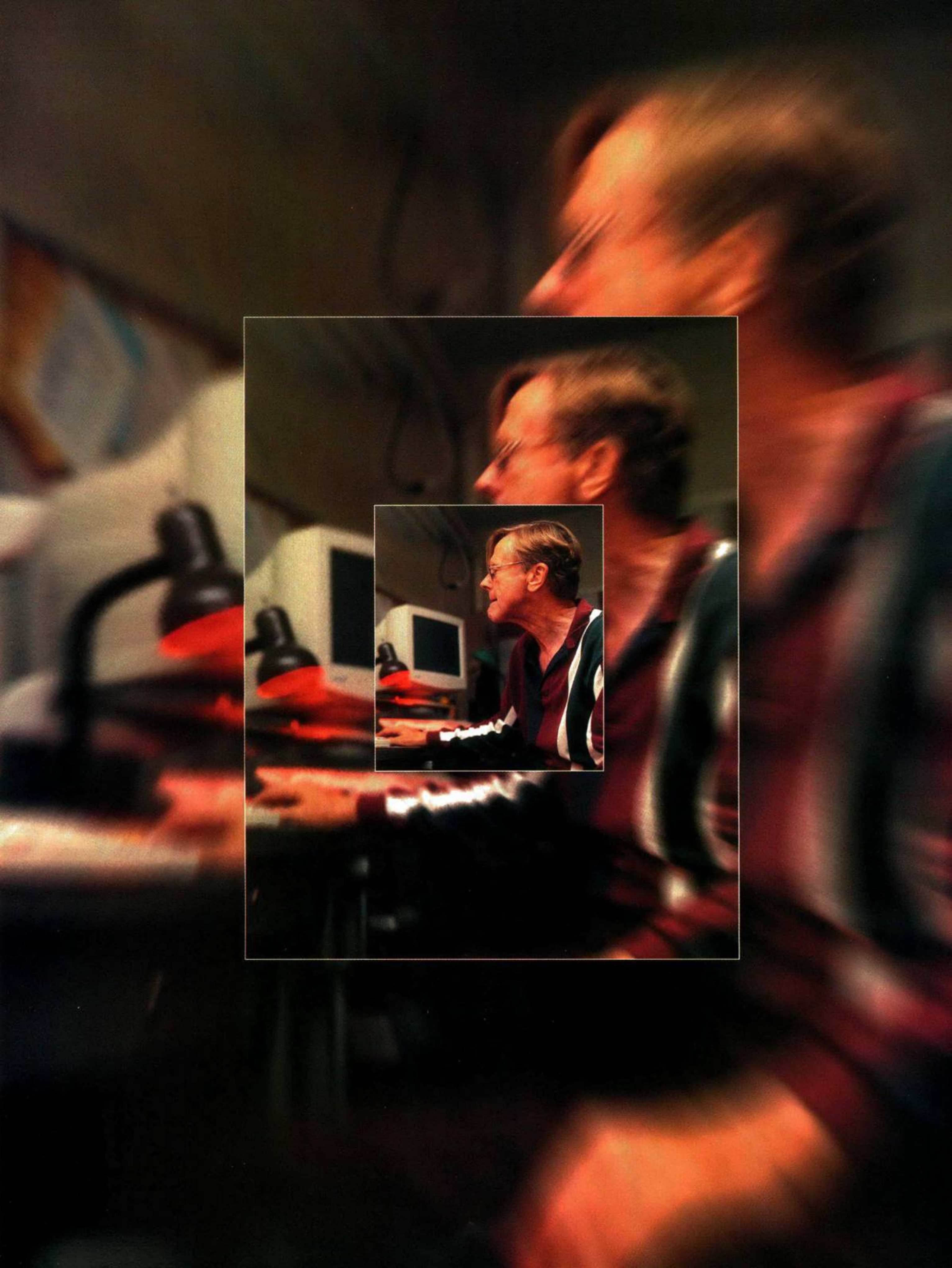
by Tony Ortega

We love to be scared by Hollywood's killer asteroids and comets, but astronomer Tom Gehrels says someday it could be for real.

Tons of vintage telescope metal creak and groan like a battleship going down in heavy seas. The 79-year-old telescope — with the diameter of a car and as tall as a house — swings toward a collision with a metal walkway inside a darkened dome. Spotting the danger, University of Arizona astronomer Tom Gehrels nimbly leaps and slaps a big red knob marked "Panic Button."

The telescope dedicated to searching for asteroids on collision courses with Earth suddenly stops. Disaster is averted yet again. Gehrels nonchalantly grabs a metal control box suspended from an electrical cable and steers the world-famous Spacewatch telescope alternately port and starboard out of harm's way. "Every half hour I move the telescope and dash up here to check it with a flashlight," Gehrels says in a calm Dutch accent. "If the telescope hit any of the steel struts of the dome it would be the end of the whole project."

All photos by Casey McKee



AIR FORCE TELESCOPE PREEMPTS COMET HUNTERS

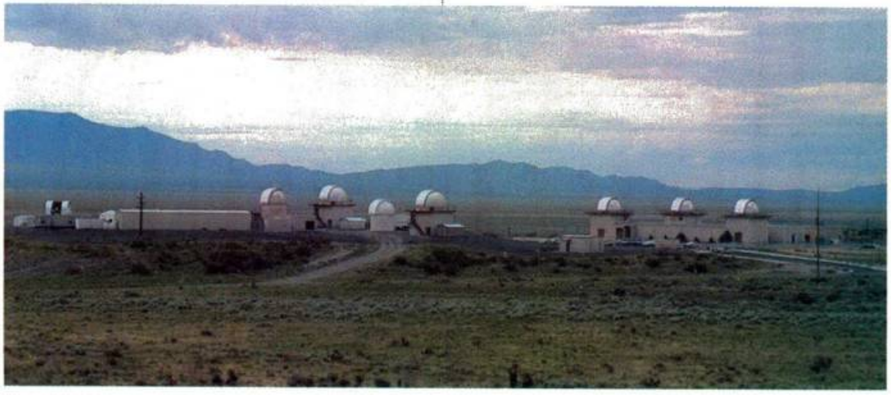
The Minor Planet Center (MPC) at the Harvard-Smithsonian Center for Astrophysics in Cambridge, Massachusetts, receives about 10,000 position reports of known and new asteroids and comets a month. But beginning in March 1998, a single Air Force telescope has swamped the MPC. The telescope submitted 160,000 observations in September alone — sending a shudder of disbelief through the world's astronomical-research community.

The little known, high-tech military telescope run by scientists from the Massachusetts Institute of Technology's Lincoln Laboratory has, virtually overnight, become the world's preeminent tool for finding asteroids and comets. The LINEAR observatory, short for Lincoln Near-Earth Asteroid Research, uses a state-of-the-art telescope with super-fast light detectors to find so many asteroids that astronomers don't even try to keep track of them all. It is finding such an abundance of near-Earth asteroids, main-belt asteroids, and comets that astronomers are stunned. Comets named after people could be a thing of the past.

"In five years, LINEAR will have mapped everything in the solar system right down to the crumbs," says an envious Brian Skiff, an astronomer who searches for comets and near-Earth objects at Lowell Observatory in Flagstaff, Arizona.

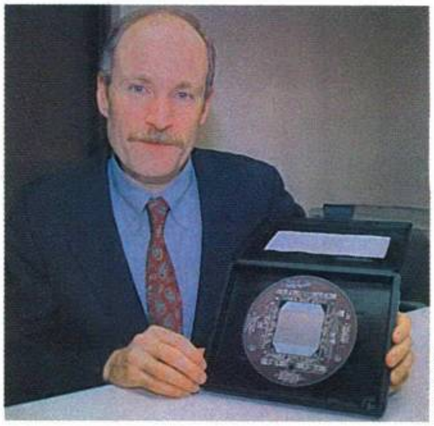
Until *Astronomy's* visit, MIT's Lincoln Laboratory had permitted only one film crew to see the telescope. Grant Stokes, an astrophysicist who runs the program from MIT, also in Cambridge, agreed to let me see the installation. It is located in a patrolled, high-security area on the White Sands Missile Range about a mile from Trinity Site, where the first nuclear bomb was detonated on July 16, 1945.

The LINEAR observatory is a squat, sheet-metal building surrounded by eight small observatory domes. Most of them are used in Ground-based Electro-Optical Deep Space Surveillance, or GEODSS, a program that keeps track of about 9,500 man-made objects that orbit Earth. With GEODSS, the United States can see everything from astronaut gloves to foreign spy satellites whizzing by overhead. LINEAR uses just one of the telescopes in one of the domes.



The LINEAR observatory is on the White Sands Missile Range in New Mexico.

Lincoln Laboratory



Peter Trujillo

Astrophysicist Grant Stokes displays a 5-million pixel CCD array at the heart of his scope.

Stokes greeted me at the observatory, beaming like an astrophysicist who had revolutionized astronomy's way of detecting asteroids. He led me down a hallway past a bulletin board with a "Technology Protection" notice pinned to it. The notice stated:

> To maintain our lead, secrecy is essential. The intelligence threat to the U.S. has not disappeared. Even some of our allies have organized intelligence operations dedicated to acquiring U.S. technology. Technology protection is the best countermeasure. Let's all do our part to prevent future leaks.

At the end of the hallway we found a conference room where we sat and talked about how his technology had leap-frogged

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For decades, Gehrels has pursued a branch of astronomy that, until recent years, garnered little attention. Gehrels and his telescope on Kitt Peak in southern Arizona have fueled the current asteroid-movie mania, if not the absurd plots or astronauts with attitudes and chin stubble. Print journalists have dubbed him a man-who-would-save-planet-Earth, and Hollywood directors morphed him into the obligatory secretive, devious scientist who tells the president things such as, "The thing is the size of Siberia, sir. Best to get underground and not tell the Russians."

Gehrels, like many scientists, is difficult to categorize. He grew up in the Dutch Reformed Church but after an agnostic period became deeply attracted to India and its people for their holistic fusion of science and Eastern faith. In his autobiography, *On the Glassy Sea: An Astronomer's Journey*, Gehrels writes about parachuting into Holland as a resistance fighter in World War II. The biography recounts his tutelage under such astronomy giants as Jan Oort, Gerard Kuiper, and George Van Biesbroeck. Gehrels studied and classified asteroids, worked on the Pioneer space missions, and founded Spacewatch in 1981.

Gehrels agreed to a few hours of face time with me and warned me not to be late. At our appointed time, he drives a government sedan into a parking lot surrounded by 21 gleaming white domes. I am light-headed from the altitude, more than 4,000 feet above the desert and the nearby Tohono O'odham Indian town of Sells. We walk to a cafeteria, fill our plates with vegetarian dishes, and sit with other scientists.

As we eat, Gehrels says it is not correct, as some journalists have suggested, that we probably will have no warning before the others. Stokes opened up a black-plastic case and showed me a single, four-inch silicon wafer. It is similar to the silicon wafers that microprocessor manufacturers like Intel Corporation carve up into small chips. But this entire wafer was a chip the size of a generous cookie. It was the LINEAR CCD, or charge-coupled device light detector.

The CCD has 5 million pixels, or picture elements, arranged in a 1960- by 2560-pixel array. The LINEAR chip is back-illuminated, meaning that instead of losing precious light-gathering potential to a lattice of wiring that connects pixels, electrical connectors that connect each pixel are etched into the chip. As a result, the chip is as thick as aluminum foil and has twice the light-gathering capacity of a conventional CCD.

Astronomers wait up to two minutes for data from a conventional CCD to be recorded, whereas the LINEAR CCD reads all of its pixels in a few milliseconds. Stokes showed me how the chip manages it. Above and below the light-gathering area there are highly reflective areas that he calls "frame stores." They're effectively 5,000 parallel channels through which the information stored on the millions of pixels can be rapidly shifted.

The information is read by a computer via eight parallel channels of fiber optic lines. The LINEAR chip soaks up enough starlight to detect faint, 19th-magnitude stars in only 10 seconds. The chip then dumps the information into a computer so fast, the chip is ready for the next frame without having to use a shutter.

LINEAR's 1-meter telescope is housed in a small dome outside the metal building. Eric Pearce, the on-site astronomer who manages the facility, simply removes a cloth cover before working each evening. The scope runs itself automatically. The telescope's mount was built for quick slewing-and-stopping. It makes asteroid detection seem like child's play.

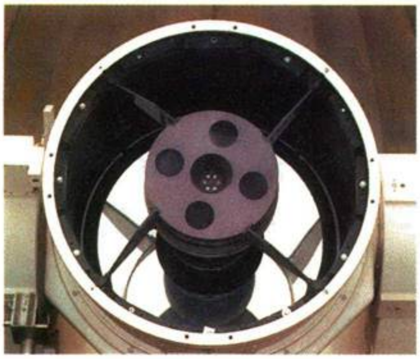
Taking rapid snapshots, it has time to take five images of each piece of sky. The scope photographs most of the night sky during 10 nights of observing each month.

Powerful computers layer the five pieces on top of one another. With a push of a button, software gobbles up thousands of stars on the screen. Suddenly, the only objects remaining on the screen are a handful of objects the software decides are asteroids and comets.

"If you're willing to take five frames, the software has a very good performance with respect to probability of discovery and a very low false-alarm rate," says Stokes in his understated, technical way. "The Minor Planet Center tells us that when we sweep through an area we find everything we're supposed to find: everything they know about, plus stuff they don't know about."

The results have been astonishing. Since LINEAR went on line at full speed in March 1998, the project has swamped the MPC with new discoveries. Of the 147 total near-Earth objects found in all observatories between March and November, LINEAR discovered 102 of them. Of the objects discovered during that period that were 0.6 miles (1 km) or larger — the size considered large enough to cause climatic disruptions on Earth — LINEAR discovered 26 of the total 38. Of 28 comets discovered in the same period, LINEAR had its name attached to 13 of them.

The 1-meter LINEAR telescope found 19,293 asteroids in its first 10 months of operation.



Lincoln Laboratory

By January 3, overworked orbit calculators at the MPC had given designations to 19,293 new asteroids discovered by LINEAR in only 10 months of operation. That is only 5,984 fewer asteroids than Spacewatch discovered in 16 years. "The MPC is going to have to get some new computers," Stokes says with a satisfied grin. "We will want to coordinate searches with astronomers . . . I think a lot of people would like to get that chip."

Stokes studied physics at Princeton University, where he hunted for pulsars with a radio telescope. After graduation, he became interested in surveillance. He and his colleagues at Lincoln Laboratory developed the LINEAR CCD in an effort to assist the Air Force's Space-Based Space Surveillance program. The Air Force has spent about $1 million over the past three years to fund Stokes' proposal.

Stokes says all of LINEAR's observations are sent directly to the MPC. That means the MPC, not LINEAR, will discover the next asteroid on a collision course with Earth. "They'll tell us about it, not the other way around," Stokes says.

— Tony Ortega

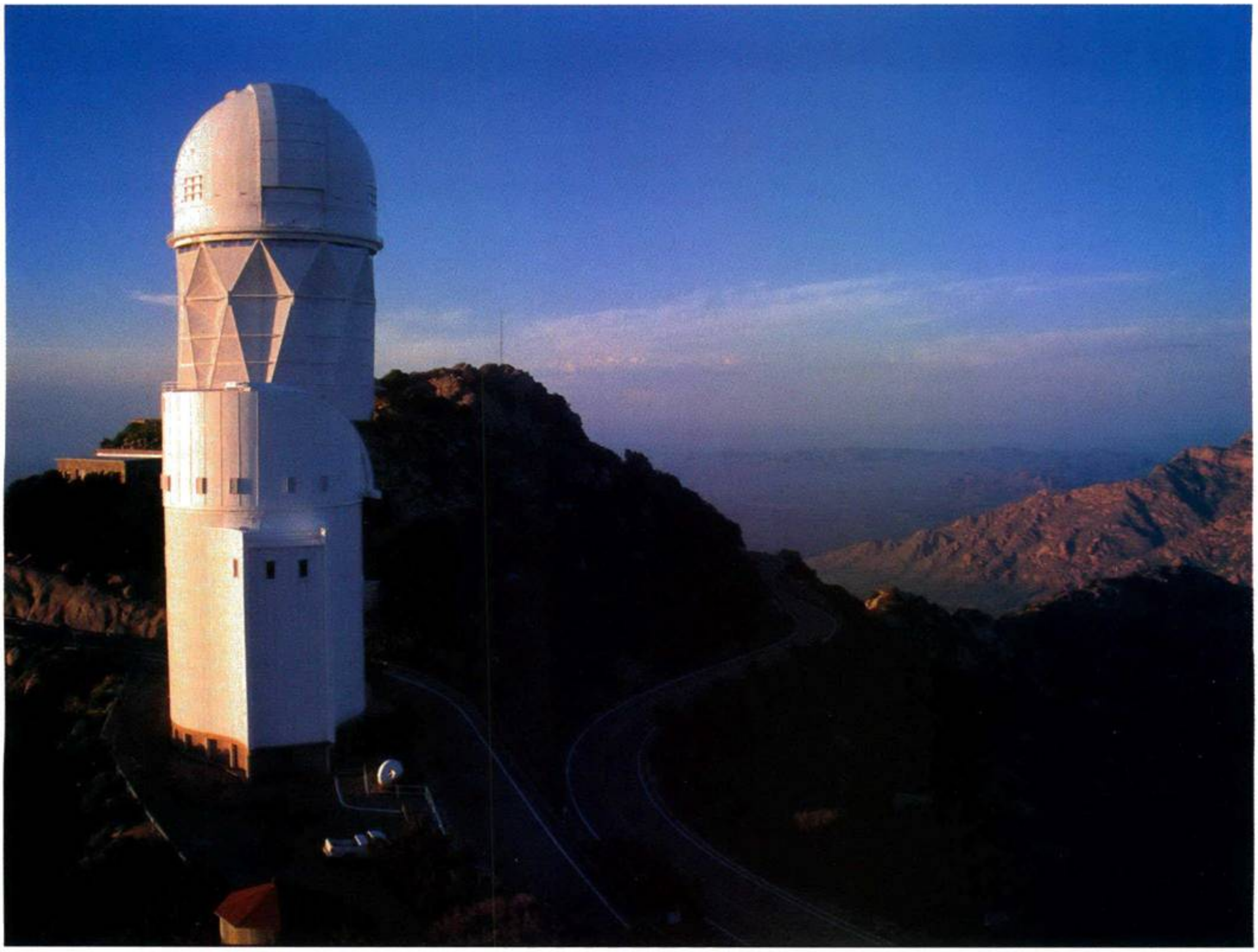
a giant asteroid slams into Earth. It's most likely we'll have decades to prepare for an asteroid headed our way. It was his Spacewatch colleague Jim Scotti who found the one-mile-wide asteroid 1997 XF_{11}, which in the hours immediately after its discovery was thought by some to be hurtling almost directly at us.

On March 11, 1998, the Minor Planet Center announced there was a chance that XF_{11} would pass only 28,000 miles (45,000 km) from Earth. Initial estimates of the probability of a collision in 2028 ran as high as a discomforting 1 in 1,000. One day later, refined calculations based on earlier sightings showed that XF_{11} would miss Earth by 625,000 miles (1 million km). That's a relief, but what about reports that the only warning we might get of a catastrophic collision would be a brief rumble and a blinding flash of light?

"Who says such things?" Gehrels complains. He seems dubious that a NASA scientist would tell the *Washington Post* that the next mass-extinction impact will most likely occur without warning. He warns me not to repeat the mistake.

A *Boston Globe* reporter also exasperated Gehrels with his descriptions of a night's observing here. Gulp. I am about to witness the same thing. With my dinner settling uneasily in my stomach, we drive to the Steward Observatory. It has housed the 0.9-meter Spacewatch telescope since 1962.

Gehrels begins the night's work by pouring liquid nitrogen into a pail and carrying the steaming container upstairs. He pours the –320° F (–196° C) bubbling liquid through a funnel into a reservoir, which cools the CCD, or charge-coupled device camera. Some of the liquid spills, hissing noisily on the platform.



The view from Gehrels' Spacewatch Telescope on Kitt Peak, Arizona, includes the WIYN Observatory (foreground) and the Mayall 4-meter Telescope (background).

Gehrels previously propped the funnel into position with a broomstick. Hey, it worked, he says, so why change it? However, Gehrels was exasperated when the *Globe* reporter wrote that the astronomer holds up his CCD with a broom. "Among my colleagues this wasn't funny at all," he complains.

Does he regret the sudden national attention? Did *Deep Impact* and *Armageddon* change anything? "I don't know," he says. "I can't tell. Things may have changed because of XF_{11}. That did bring a scare or a realization. I think the upshot of that event was, well, it didn't happen this time but it could have happened, and the next time it could be for real."

Gehrels says it is not correct, as some journalists have suggested, that we will probably have no warning before a giant asteroid slams into Earth.

What should we do if an asteroid is found to be on a 30-year collision course with us? Gehrels says blasting it with nuclear bombs is unwise because the shotgun pellets are just as likely to hit us as the single slug of an asteroid. However, an unmanned rocket could deliver more modest chemical explosives that could nudge the asteroid or comet with just enough energy to cause it to miss Earth by a comfortable margin.

Gehrels also says that the chances for a civilization-ending impact are greater than most people realize. He challenges me to guess the odds of an impact of a killer asteroid in any one human's lifetime. I suggest one in 1 million because it has been 65 million years since the impact that many believe led to the extinction of the dinosaurs.

"No. One in five thousand," he says. He explains that such a collision occurs once in 330,000 years — the dinosaur-killer was probably a rare 6- to 7-kilometer (3.7- to 4.4-mile) monster. Since the average human lives about 66 years, you end up with 1-in-5,000 odds. Chilling. I wondered whether Gehrels actually looks forward to the discovery of such an asteroid as vindication of his research.

"There was a wish," he answers tentatively, "during the Cold War." Asked to elaborate, he says he had thought that a menacing asteroid might force nations to cooperate to avert disaster.

After pouring the liquid nitrogen, Gehrels descends into what passes for a control room. Surrounded by four computers, he reviews notes scribbled earlier by his colleague Scotti.

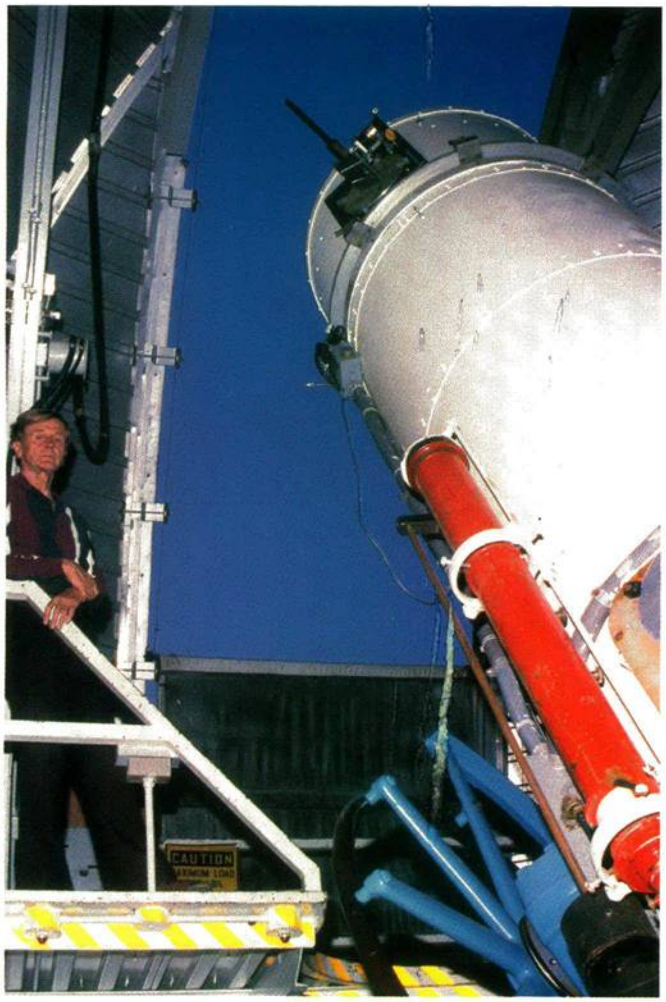
Gehrels explains how the electronic detector and software work together while he points the telescope in the direction of a recently discovered comet. As the CCD begins to take its exposure, the Spacewatch computer purposely does, on cue, what all amateur astrophotographers dread — it turns off the telescope's clock drive.

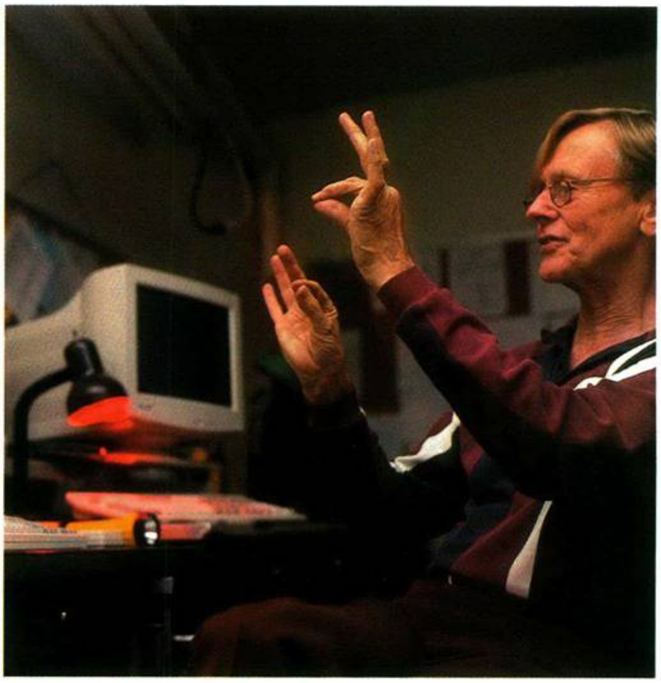
Rather than getting smeared images, however, the computer reads out a continuously scanning image as the stars move across the telescope's aperture. The process allows the CCD to scan a large piece of sky, yet does so slowly enough to detect objects in motion — such as asteroids and comets. Gehrels routinely runs three 5-minute scans of the same portion of sky. It's an ingenious solution to a problem of limited resources.

> Gehrels and astronomers at the Minor Planet Center fear that an asteroid will be jostled by the gravity of Jupiter and be set off on a collision course with Earth.

In the morning, the Spacewatch computers compare scans to find moving objects and plot their positions. During observations, the computer does its best to identify elongated objects, such as comets, for Gehrels to inspect. The great majority of the elongated smears of light prove to be distant galaxies or artifacts. He dismisses them.

Gehrels ignores the first 12 objects the computer had flagged for consideration but stops on number 13. "This is interesting," he says. Number 13 had moved considerably in a mere 5-minute scan — the unmistakable sign of a rock moving through space not far from Earth. It could have been a hazardous near-Earth asteroid that could bring Spacewatch even more notoriety. A few days later, however, Gehrels tells me that number 13 is a previously known asteroid whose orbital inclination is different from Earth's.





ABOVE: Gehrels says blasting asteroids with nuclear bombs would only turn a single slug into shotgun pellets.
LEFT: The 79-year-old Spacewatch telescope is responsible for the discovery of dozens of comets and 25,277asteroids.

The chance of finding an object that is coming directly at us is low. Gehrels and other asteroid-watchers spend night after night finding positions of previously discovered asteroids and comets for the Minor Planet Center (MPC). The MPC is a clearinghouse at the Harvard-Smithsonian Center for Astrophysics in Cambridge, Massachusetts, that compiles thousands of observations and constantly computes updated orbits. The ongoing effort is needed to find potentially hazardous objects. Gehrels and astronomers at the MPC fear that, most likely, a nearby asteroid will be jostled by the gravity of Jupiter and set off on a new path for a future collision with Earth.

I climb the steel stepladders to a hatch at the top of the dome. Looking up, it's easy to feel like the captain of an airborne battleship plying the Milky Way. Below deck, Gehrels is the solar system's air traffic controller, patiently staring at computer screens, looking for hazards along the way. ■

Tony Ortega writes for the Phoenix New Times, Astronomy, *and other publications. His most recent story for* Astronomy *was "High Priests of Astronomy" in the December 1998 issue.*

THE SKY SHOW

This year, April proves to be anything but "the cruelest month." The warm winds of spring usher in the season of galaxies, while the planets dance among the stars. By Martin Ratcliffe and Alister Ling

A dazzling array of planets is on view during April evenings with Venus, Saturn, and Mars dominating the sky. Add to this trio one of the year's regular meteor showers and a fine occultation of Aldebaran by the moon and you've got an exciting spring for observers.

Start your evening with the ringed planet. Because **Saturn** is in conjunction with the sun on April 27, it sets early and by mid-month is lost in the solar glare.

Venus remains the brightest planet in the sky. It stands high above Saturn early in the evening. These two objects had a dramatic conjunction last month. On April 11, Venus meets another beautiful object as it passes less than 3° south of the Pleiades (M45) star cluster in Taurus. This event provides a spectacular opportunity for astroimagers to fire off a roll of color film. For the best results, vary the exposures from 5 to 30 seconds.

On April 18 a slender crescent moon crosses the Hyades just south of Venus, creating another wonderful photographic opportunity. The moon also occults Aldebaran shortly after 9 P.M. CST for most observers in the northwestern and north-central regions of the United States.

During the month, Venus continues moving north of the Hyades and lies 7° north of Aldebaran on April 21. Through a telescope, Venus exhibits a shrinking phase — changing from an illumination of 80 percent to 69 percent over the course of the month. Its apparent diameter, although growing in size as Venus and Earth move closer to one another, remains tiny and only reaches 16" by April 30.

Mars is at its best this month. The Red Planet rises in the east two hours after sunset and shines at a brilliant magnitude –1.1 on April 1. On April 24, Mars reaches opposition (opposite the sun in our sky) and

Brilliant Venus continues to dazzle. Even those living in cities can watch its progress through the evening sky.

Kevin Moan

APRIL 1999

1 Jupiter is in conjunction with the sun, 1 A.M. EST

3 The moon passes 3° north of Mars, 3 A.M. EST

4 The moon is at apogee (252,026 miles from Earth), 5:31 P.M. EDT

8 Last quarter moon is at 10:51 P.M. EDT

10 The moon passes 1.1° north of Neptune, 5 A.M. EDT

11 The moon passes 1.0° north of Uranus, 3 A.M. EDT

13 The moon passes 1.1° south of Mercury, midnight EDT

16 New moon is at 12:22 A.M. EDT
Mercury is at greatest western elongation (28°), noon EDT

17 The moon is at perigee (223,007 miles from Earth), 1:26 A.M. EDT

18 Asteroid Metis is at opposition, 9 A.M. EDT
The moon passes 7° south of Venus, 5 P.M. EDT
The moon passes 0.7° north of Aldebaran, 10 P.M. EDT (page 70)

20 Asteroid Pallas is in conjunction with the sun, 7 P.M. EDT

21 Venus passes 7° north of Aldebaran, 4 P.M. EDT

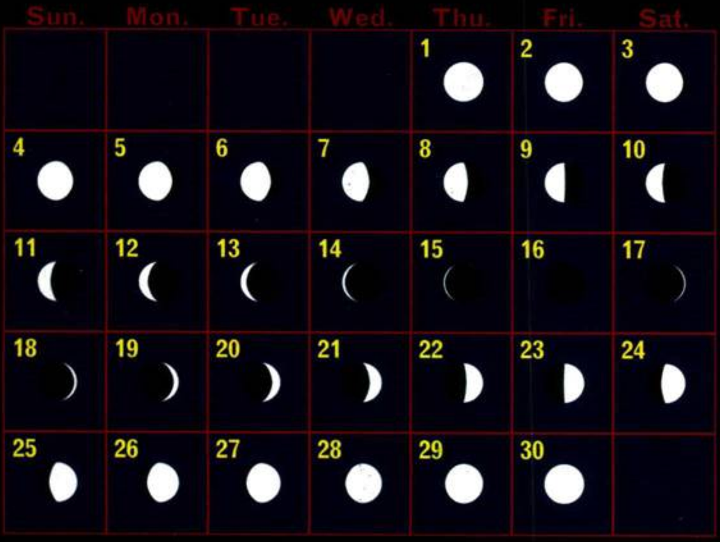
22 Lyrid meteor shower peaks (page 73)
First quarter moon is at 3:01 P.M. EDT

24 Mars is at opposition, 2 P.M. EDT (page 72)
The moon passes 0.5° north of Regulus, 5 P.M. EDT (page 70)

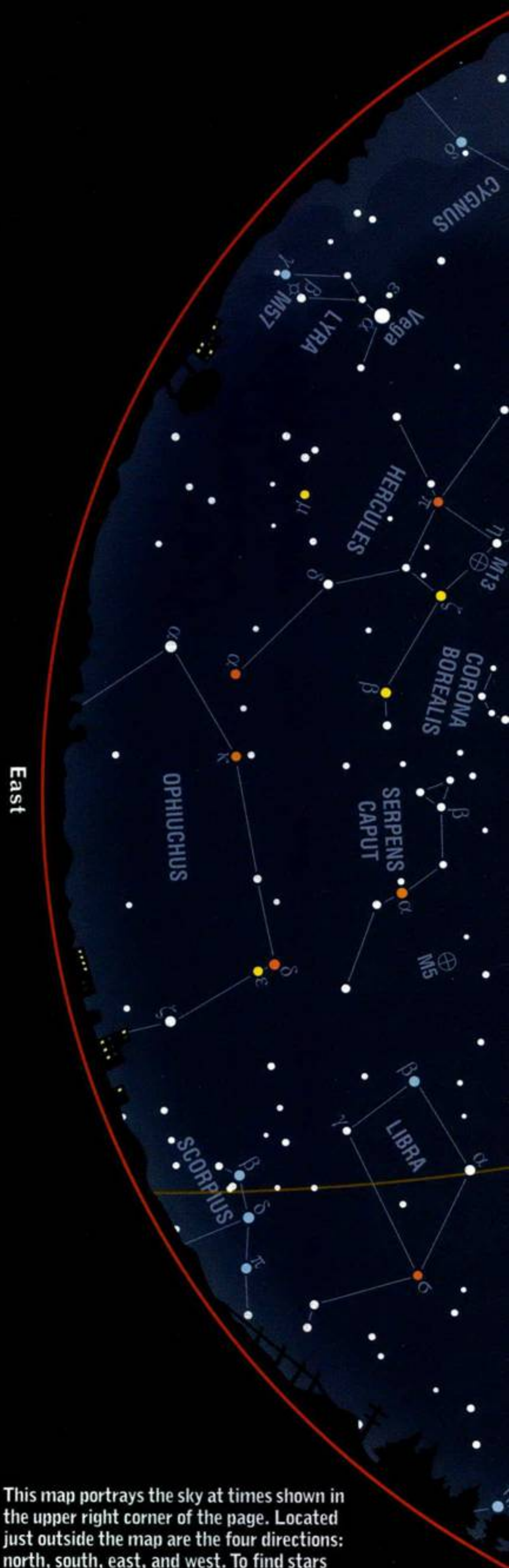
27 Saturn is in conjunction with the sun, 7 A.M. EDT

29 The moon passes 4° north of Mars, 5 P.M. EDT

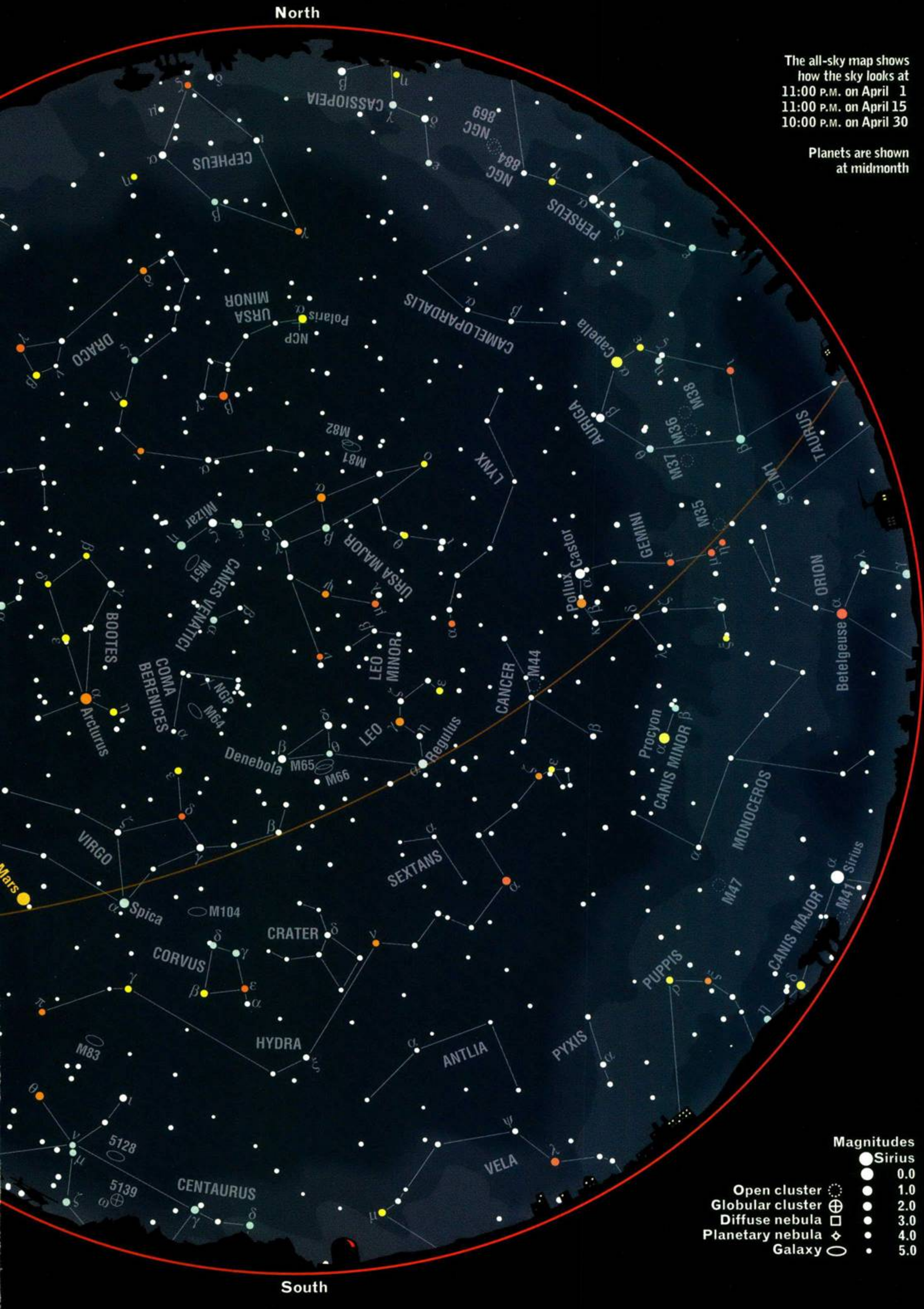
30 Full moon is at 10:55 A.M. EDT



Sun.	Mon.	Tue.	Wed.	Thu.	Fri.	Sat.
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	



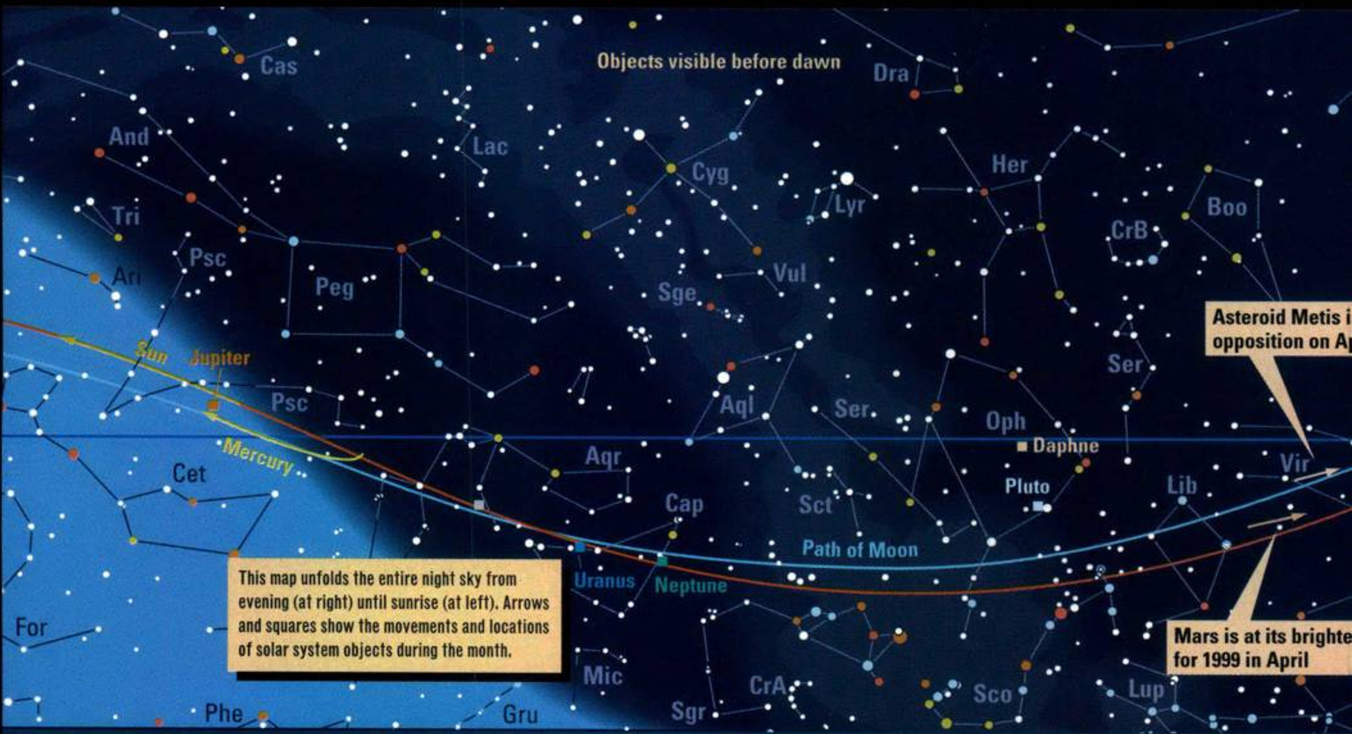
This map portrays the sky at times shown in the upper right corner of the page. Located just outside the map are the four directions: north, south, east, and west. To find stars above your horizon, hold the map overhead and orient it so a direction label matches the direction you're facing. The stars above the map's horizon now match what's in the sky.


North
South
West
CASSIOPEIA
CEPHEUS
NGC 869
NGC 884
PERSEUS
URSA MINOR
Polaris
NCP
DRACO
CAMELOPARDALIS
Capella
AURIGA
M36
M38
M37
TAURUS
M1
M82
M81
LYNX
Mizar
URSA MAJOR
M51
CANES VENATICI
M35
GEMINI
Castor
Pollux
ORION
Betelgeuse
BOOTES
COMA BERENICES
NGP
M64
Arcturus
LEO MINOR
CANCER
M44
LEO
Regulus
Denebola
M65
M66
Procyon
CANIS MINOR
MONOCEROS
VIRGO
Mars
Spica
M104
SEXTANS
CRATER
CORVUS
M47
Sirius
M41
CANIS MAJOR
PUPPIS
HYDRA
ANTLIA
PYXIS
M83
5128
5139
CENTAURUS
VELA
Magnitudes
Sirius
0.0
1.0
2.0
3.0
4.0
5.0
Open cluster
Globular cluster
Diffuse nebula
Planetary nebula
Galaxy

The all-sky map shows
how the sky looks at
11:00 P.M. on April 1
11:00 P.M. on April 15
10:00 P.M. on April 30

Planets are shown
at midmonth

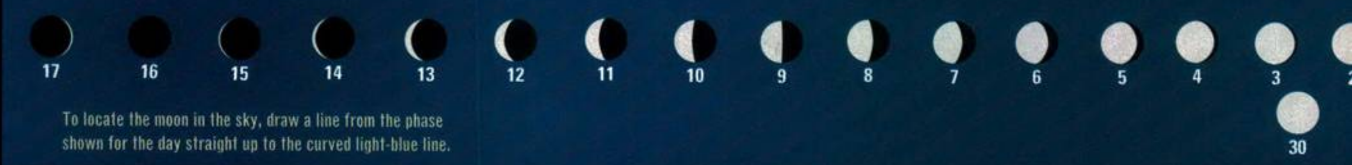
THE PATH OF THE PLANETS


Cas
Objects visible before dawn
Dra
And
Lac
Cyg
Lyr
Her
Boo
Tri
Psc
Ari
Peg
Sge
Vul
CrB
Sun
Jupiter
Psc
Aql
Ser
Oph
Ser
Daphne
Mercury
Aqr
Cet
Cap
Sct
Pluto
Lib
Vir
Path of Moon
Uranus
Neptune
For
Mic
CrA
Sco
Lup
Phe
Gru
Sgr

This map unfolds the entire night sky from evening (at right) until sunrise (at left). Arrows and squares show the movements and locations of solar system objects during the month.

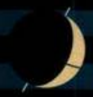
Asteroid Metis i
opposition on Ap

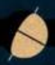
Mars is at its brighte
for 1999 in April

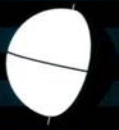

17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
30

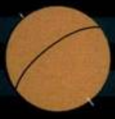
To locate the moon in the sky, draw a line from the phase shown for the day straight up to the curved light-blue line.

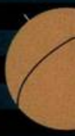
PLANETS	MERCURY	MERCURY	VENUS	MARS	MARS
Date	April 1	April 30	April 15	April 1	April 30
Magnitude	1.6	−0.1	−4.0	−1.1	−1.6
Angular Size	10.3"	6.3"	14.5"	14.0"	16.2"
Illumination	18%	66%	75%	97%	100%
Distance (AU) from Earth	0.654	1.061	1.147	0.670	0.579
Distance (AU) from Sun	0.444	0.431	0.718	1.613	1.583
Right Ascension (2000.0)	23h25.9m	1h01.3m	4h02.1m	14h37.2m	14h01.4m
Declination (2000.0)	−3°00'	3°33'	22°14'	−13°15'	−11°09'





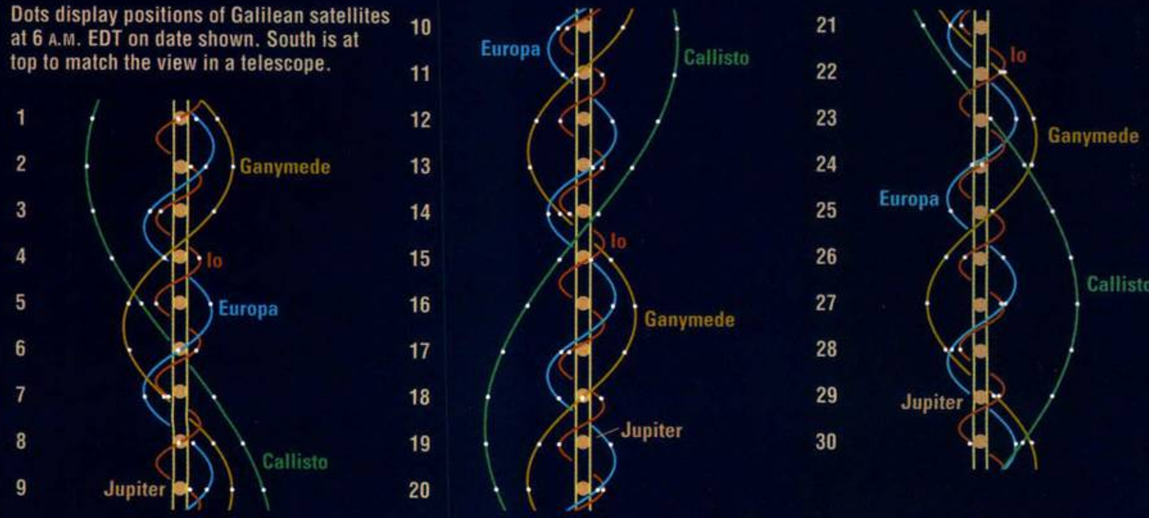


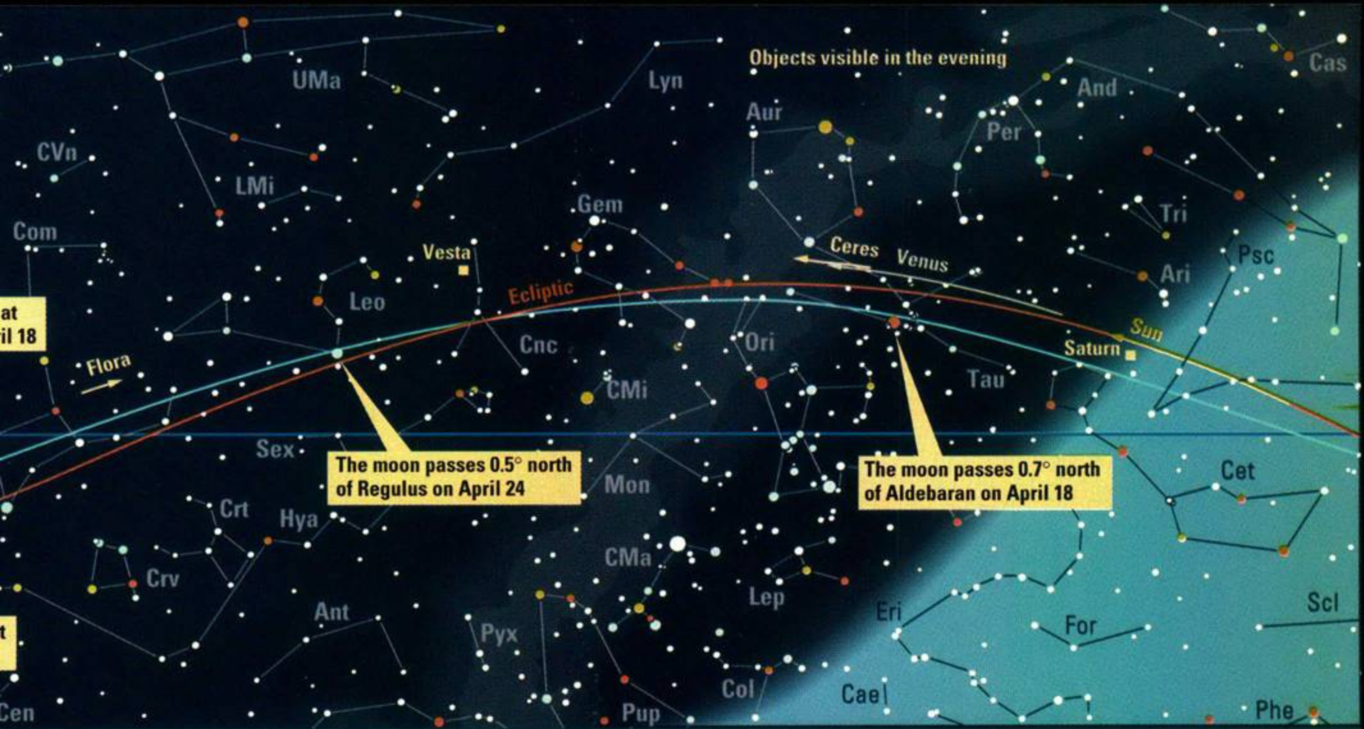




JUPITER'S MOONS

Dots display positions of Galilean satellites at 6 A.M. EDT on date shown. South is at top to match the view in a telescope.




Objects visible in the evening
Cas
UMa
Lyn
Aur
And
Per
CVn
LMi
Gem
Tri
Com
Vesta
Ceres
Venus
Psc
Ari
Leo
Ecliptic
at
il 18
Cnc
Ori
Sun
Saturn
Flora
CMi
Tau
Sex
The moon passes 0.5° north of Regulus on April 24
Mon
The moon passes 0.7° north of Aldebaran on April 18
Cet
Crt
Hya
CMa
Crv
Lep
Scl
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For
Pyx
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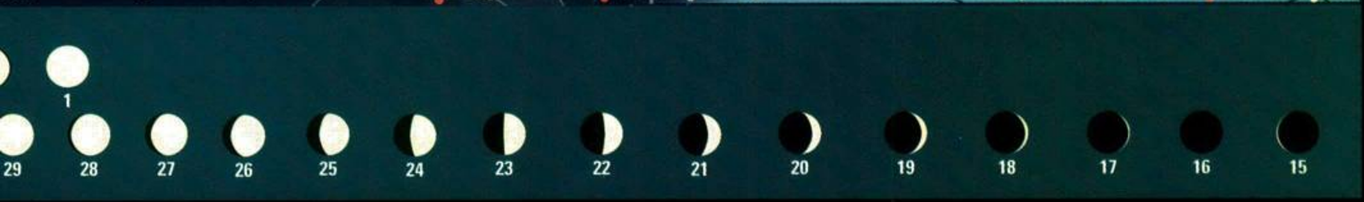
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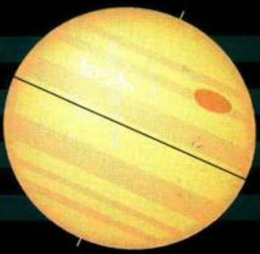
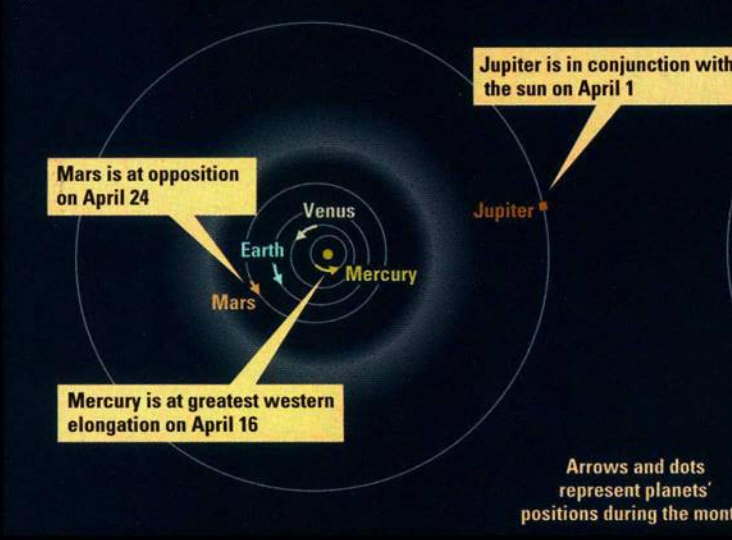
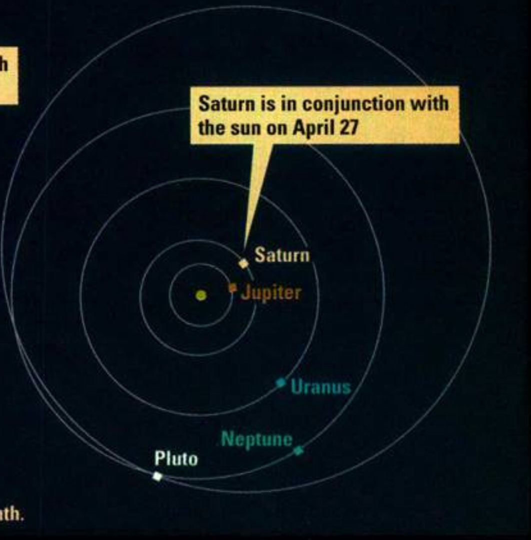


JUPITER	SATURN	URANUS	NEPTUNE	PLUTO
April 30	April 1	April 15	April 15	April 15
−2.1	0.4	5.8	7.9	13.7
33.6"	16.4"	3.5"	2.3"	0.1"
100%	100%	100%	100%	100%
5.875	10.161	20.246	30.281	29.454
4.951	9.247	19.897	30.130	30.149
1h07.9m	2h07.9m	21h15.7m	20h26.0m	16h41.3m
6°02'	10°35'	−16°35'	−18°55'	−10°17'

THE PLANETS IN THEIR ORBITS


Jupiter is in conjunction with the sun on April 1
Mars is at opposition on April 24
Venus
Jupiter
Earth
Mercury
Mars
Mercury is at greatest western elongation on April 16


Saturn is in conjunction with the sun on April 27
Saturn
Jupiter
Uranus
Neptune
Pluto

Arrows and dots represent planets' positions during the month.

FIRST VIEWS: Virgo Cluster North

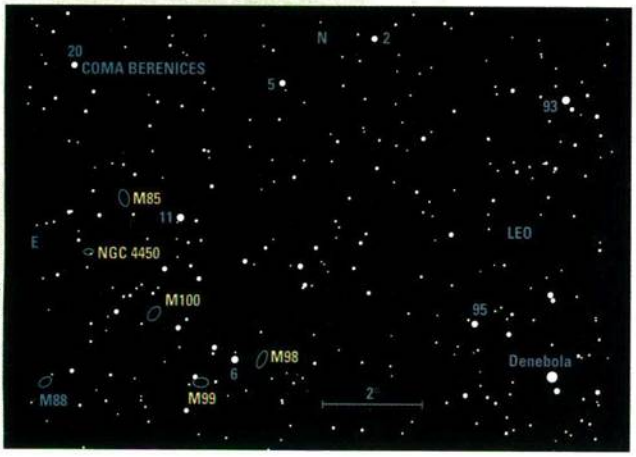
The Virgo Cluster of galaxies is a lot easier to find and observe when you take it one step at a time. The northern section is an easy first step. If you stick to the stellar landmarks, you won't get lost.

It's important to observe the Virgo Cluster because it's the next leap outward from our Local Group of galaxies, which includes M31 and M33. The Virgo Cluster is also where observers cut their teeth galaxy hopping, instead of star hopping. Remember that a dark country sky is your first requirement. Otherwise, it's a real challenge.

We depart Beta (β) Leonis, the end of the hindquarters of Leo, where Delta (δ) and Theta (θ) Leonis help to make a bright right triangle of stars. Head east (left) in a straight line from Theta through Beta, and in about three-fourths of that distance you'll land at your first anchor star, 5th-magnitude 6 Comae Berenices.

One moon diameter (30') due west of 6 Com is M98, discovered by Messier's colleague Pierre Méchain on April 13, 1781. At 10th magnitude, this elongated galaxy is pretty bright. Head east of 6 Com by the same distance and you'll come across a 6th-magnitude star, your second anchor. From this star, drop due south by a bit more than a moon width, and you'll see the brighter M99.

Retrace your steps back to 6 Com and head in a straight line back through the second anchor. Then go another 1.5 moon widths to another star, and continue one more moon width to M100. It is the brightest of the three Messier objects in this region.



All Illustrations *Astronomy:* Elisabeth Rowan

Jack Newton

Jack Newton

Take the time to sweep back and forth between these three objects, to get a good feel for how much sky the chart covers. You may want to turn the chart upside down to match your scope's orientation. It should be easy to zig 2° north of M100 to the bright star 11 Com and zag 1° east to bright M85. Continue another degree south and east: there lies NGC 4450, slightly fainter than M98.

Once you get used to the amount of sky your scope shows, galaxy hopping through the rest of the Virgo Cluster is a straightforward and rewarding experience.

will rise as the sun sets. By midnight the Red Planet is high in the southern sky and wandering through the stars in the constellation Virgo the Maiden.

Mars shines at a bright –1.7 magnitude at opposition, brighter than the star Sirius. Its red color is unmistakable in the evening sky. Watch Mars nightly as it wanders westward in its retrograde path against the stars of Virgo.

At this opposition, Mars will be within 54 million miles of Earth. The closest Mars can approach is 35 million miles. The next time such a close opposition happens will be in 2003.

As Mars and Earth move closer to one another, the Red Planet's tiny disk grows in apparent size — from 14" on April 1 to 16" at opposition on April 24 (similar in apparent size to Venus on that same date). While this is large by martian standards, it represents a tiny disk through any telescope.

Patience is required when observing Mars. You must wait for those still atmospheric moments that allow startling detail to be seen. Only at those times of perfect seeing do the real delights of observing Mars pay off. Details such as Syrtis Major and the diminishing ice cap will be obvious to most observers. Subtler features such as Sinus Sabaeus, Aurorae Planum, and Solis Lacus require a good map of Mars to identify (see "Red Planet at Night, Observer's Delight," page 90).

While Venus and Mars dominate the evening sky of April, the stars also carry a few seasonal gems that should not be missed. Observers away from city lights will notice the Milky Way along the horizon. The final view of the winter Milky Way is carried toward the western horizon by the setting constellations Canis Minor, Gemini, Orion, Taurus, and Auriga. These "wintertime" stars will return to our skies during the early morning hours of autumn.

Because the plane of the Milky Way now rests along the horizon, it's easy to look directly out of the galaxy into intergalactic space. Though a few stars from our own neighborhood are the most obvious objects to see, the galaxies beyond those stars are there, too. A good star atlas shows how many galaxies dot this region of the sky. Try looking in Ursa Major, Leo, Virgo, and Coma Berenices. Use a good atlas and telescope for many hours of enjoyable galaxy hopping.

Virgo is a major galaxy hideout. Not only does it harbor Mars in late April, but here too are the elliptical galaxies M59 and M60. Another galaxy on the must see list is the Black Eye

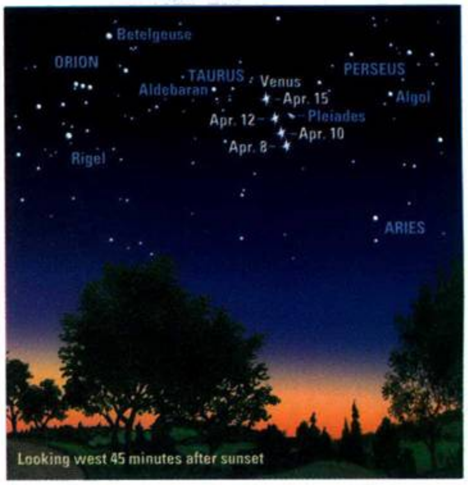
Saturn Sinks as Venus Vaults

The beautiful evening sky continues to dominate casual conversations this month. The "evening star," Venus, is climbing higher and higher into the dark sky of late twilight.

Those who are unfamiliar with the night sky can use Venus as a guide to the Pleiades (M45). The planet is within 5° (one standard binocular field of view) from the cluster on April 8 to April 15. Pay attention to the angle Venus makes with the Pleiades from night to night and you'll see how fast its smaller orbit makes it move through the sky.

Meanwhile, the softer glow of Saturn is overwhelmed by bright twilight. Can you follow it with binoculars past April 10?

Mid-month, Venus scenery buffs will get their fill again as a spectacular crescent moon floats below Venus on April 17. With luck, the dark portion of the moon will be bathed in earthshine. A grand naked-eye gathering of Aldebaran, Venus, and a fat crescent moon can be seen on April 18.

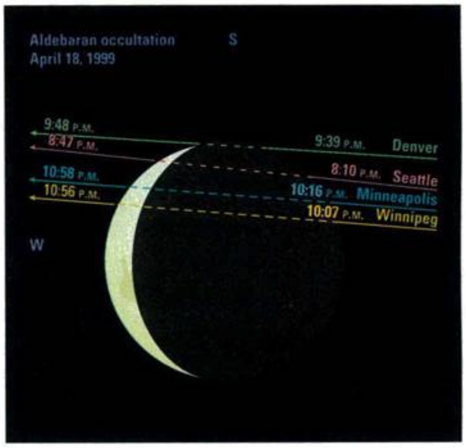


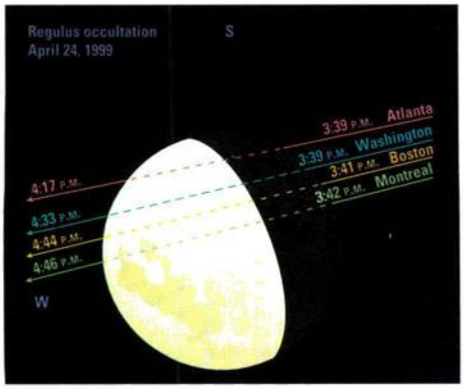
Looking west 45 minutes after sunset

The Moon's Winking Act

Those who are fortunate enough to observe from central North America can see the Moon occult two of the four brightest stars in its path, Aldebaran and Regulus, within one week's time.

On Sunday evening, April 18, Aldebaran succumbs to the dark side of the spectacular crescent moon. The diagram shows when the event will occur for those living north of a line from central Kansas to central Oregon. Observers on that line may see several disappearances and reappearances as the star moves behind mountain peaks and shines through valleys on the lunar limb.





Saturday afternoon, April 24, at roughly 4:45 P.M. EDT, Regulus will disappear behind the first-quarter moon. North American observers east of a line that extends from northern Alberta to southern Texas can see the event in a darkening sky, while western Europeans can see it in a dark evening sky.

If you want to contribute to the science of lunar occultations, visit the International Occultation Timing Association's website (http://www.sky.net/~robinson/iotandx.htm) for more information.

Galaxy (M64), so called due to a dark dust lane near the core. Look for M64 in Coma Berenices not far from the constellation's brightest star, Alpha (α) Comae Berenices. In addition, the 4th-magnitude globular cluster M53 is also in that region.

The Whirlpool Galaxy (M51) is another fine object at which to point the telescope. This beautiful spiral is just over 3° southwest of Benetnasch, the last star in the handle of the Dipper. The third Earl of Rosse, who lived at Birr Castle in Ireland, gave the galaxy its name. He was using a 72-inch reflector, the largest telescope of its time, to observe M51 when he saw its fine detail.

Four galaxy favorites can be found in pairs among the stars of Leo the Lion. First try M65 and M66. This twosome is separated by a scant 0.5° and is located midway between Theta (θ) and Iota (ι) Leonis. Try moving from Theta Leonis two thirds of the way toward Rho (ρ) Leonis. There you will find the other fine pair galaxies, the spirals M95 and M96. Numerous other galaxies pepper this region. How many can you spot?

If you need a break from the late nights of observing, try a daylight lunar occultation of Regulus. The moon occults the 1.3-magnitude star in Leo on April 24 for regions east of Texas.

In Europe, the occultation takes place shortly after 9 P.M. GMT. In the United States, the occultation occurs in daylight and somewhat earlier, approximately 2:30 P.M. EST (detailed time predictions should be used for your

OBSERVER'S CHALLENGE: The Draco Sampler

NGC 5907

Jack Newton

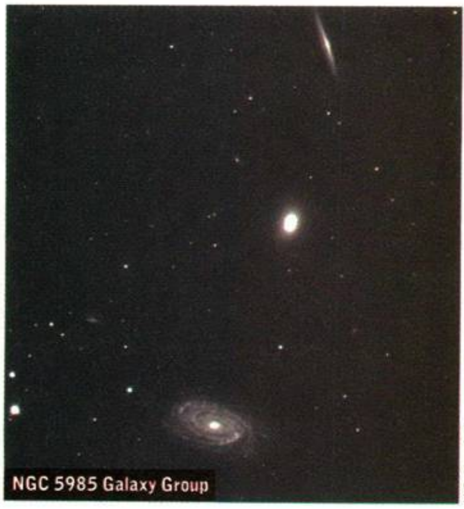
Every now and then, a real deep-sky gem comes into view. This month offers the perfect opportunity to compare views of spiral, elliptical, and edge-on galaxies in the same field. The best part about these objects is that they are not as tough to find as you might think. If they were located in a sparse region like Cancer, these galaxies would be on everyone's observing list.

To find this trio, jump from Polaris straight through the bowl of the Little Dipper and stop at a broad arc of three modest stars. By 11 P.M. in April, this arc stands on end to the east (right) of Polaris.

Halfway between Iota (ι) and Theta (θ) Draconis (the top and middle of the arc) lies the easiest of the three galaxies, NGC 5982. It lies in the middle, and you should be able to recognize this fuzzy-looking star at low power in an 8-inch scope. If you increase the power, the 11th-magnitude galaxy will reveal an intensely bright nucleus surrounded by a fainter haze.

Only 7' east lies the delicate 11th-magnitude spiral galaxy NGC 5985. Although its total brightness is slightly better than the elliptical, its light is spread out over a larger area and therefore is harder to see. As is typical of spiral galaxies, it has a modestly bright nucleus surrounded by a somewhat mottled face. This appearance is the result of its spiral arms being just below our seeing limit.

Finally, in almost perfect position on the west side of elliptical NGC 5982, lies the edge-on galaxy NGC 5981. At magnitude 13, it's the most challenging object of the three. It looks like a streak with a bright blip at its core. The only thing missing is a dust lane. If you want to see dust lanes, NGC 5907 and M102 lie only 3° away.


NGC 5985 Galaxy Group

U.S. Naval Observatory

particular location). The moon will be relatively easy to find during daylight hours, and Regulus should also be relatively easy to see in most small telescopes.

Returning to the night sky, look for the constellation Cancer the Crab just ahead of the Lion's nose. The minor planet Vesta can be found there, continuing its path among those relatively faint stars. The asteroid begins the month just over 5° north of the Beehive Cluster (M44), and its brightness fades from magnitude 7.2 to 7.6 as the month progresses. Even so, Vesta remains an easy object to spot in a pair of binoculars.

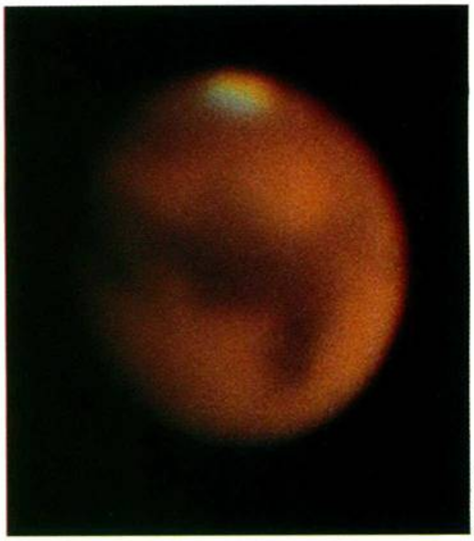
The Lyrid meteor shower, one of the year's most reliable, occurs between April 19 and April 25. Lyrid meteors typically produce 10 meteors per hour, although rates of nearly 100 per hour have been recorded during the past 200 years, most recently in 1982.

Lyrid meteors peak on April 22, though reasonable activity can be expected for a day before and after the day of maximum. With the first quarter moon setting by 2 A.M. local time, conditions are good for early morning viewing of this annual shower.

Pluto is once again the farthest planet from the Sun. It regained its ninth planet status on February 11 when it crossed outside the orbit of **Neptune**. For the past 20 years, Neptune has been the most distant planet from the Sun.

Pluto can be found in Ophiuchus 1° east-northeast of the bright star Zeta (ζ) Ophiuchi. It shines at magnitude 13.7 and is tech-

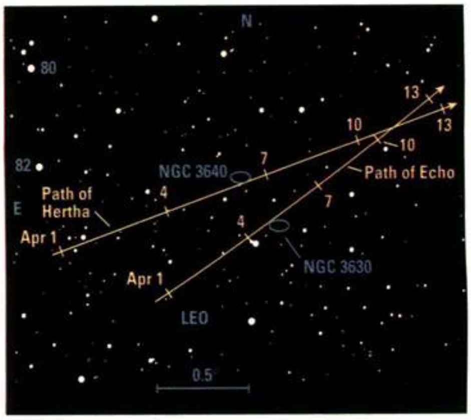
Mars at Its Max


Don Parker

Now is the time to observe Mars, as it moves toward Earth and increases in apparent size: The globe of Mars spans 14" on April 1 and grows to 16" in early May. Watch the planet's polar ice cap shrink, while dark surface shapes slowly rotate with Mars. Limb hazes will form and dissipate, and you may see the bright signs of a dust storm. The only way to distinguish these features is to spend lots of time watching Mars.

The most crucial factor in observing Mars is not equipment, but a steady sky. Atmospheric turbulence washes out the fine details, so try to avoid its sources. Make sure your scope has cooled down and Mars is not hugging the murky horizon. If the night is hazy or there is a thin layer of high cirrus clouds, you could be treated to incredibly steady images. These conditions are often present when the atmosphere is highly stable and moving without the slightest turbulence. Go ahead and push the magnification past 300x.

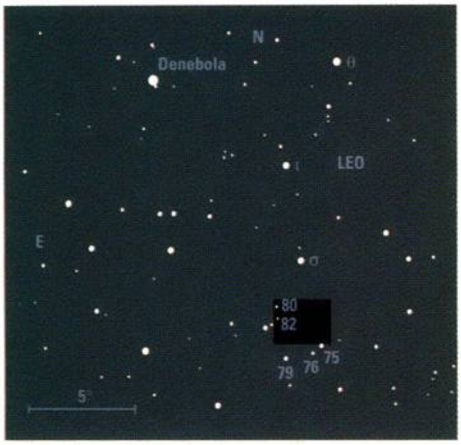
Echo in the Night



This month's asteroid is 60 Echo, the 60th asteroid to be discovered. Although there are other asteroids brighter than Echo, this small, 37-mile (60-km) wide orbiting mountain passes through some interesting galaxy fields.

On April 5, after 9 P.M. and before moonrise at around midnight, magnitude 11.1 Echo slides a mere 3' north of the 12.5-magnitude galaxy NGC 3630. The brighter 11th-magnitude galaxy NGC 3640 lies only 17' to the northeast. A real bonus happens on April 6, when the 12.4-magnitude asteroid, 135 Hertha, passes between the galaxies NGC 3640 and its diminutive companion, magnitude 14.1 NGC 3641. By the night of the 11th, Hertha and Echo are a scant 4' apart.

It's a straightforward star hop to reach this area from the hindquarters of Leo. Begin by dropping south from Iota (ι) Leonis through Sigma (σ) Leonis, but stay north of the arc formed by the stars 75, 76, and 79 Leonis.



nically visible in an 8-inch telescope under ideal conditions. Place the bright star just outside your field of view to reduce its glare. Pluto reaches opposition at the end of May when it will lie due north of 2.6-magnitude Zeta Ophiuchi.

Uranus and Neptune rise during the early morning hours and appear above the southeastern horizon well before dawn late in the month. Neptune is first to rise and lies toward the western end of Capricornus the Sea Goat. The 7.9-magnitude planet lurks about 1° east of magnitude 5.3 Sigma (σ) Capricorni.

Uranus appears about 2° east of magnitude 4 Theta Capricorni. Uranus shines at magnitude 5.8, which is detectable in binoculars.

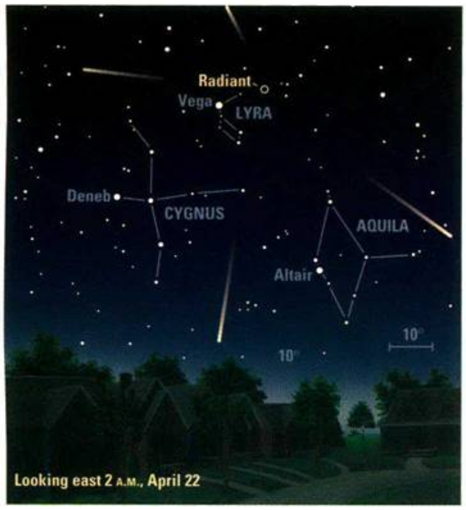
Mercury reaches greatest elongation (28°) west of the sun on April 16, just three days after it passes through its aphelion point (the farthest orbital point away from the sun). However, Mercury's southerly declination means it's not well placed for Northern Hemisphere observers. On the other hand, Southern Hemisphere observers will get a fine morning view before dawn.

Joining Mercury's game of hide and seek in the solar glare is **Jupiter.** It's in conjunction with the sun on April 1, and begins to climb away from the sun into the morning sky. Next month the –2-magnitude planet begins to reappear before dawn above the eastern horizon.

Martin Ratcliffe is Director of Theaters at the Exploration Place in Wichita, Kansas. Alister Ling is a meteorologist working for Environment Canada in Alberta.

April Meteor Shower

The one event guaranteed to turn heads and draw shouts from an observing crowd is the streak of light called a meteor. These "shooting stars" are interplanetary dust specks that come to a sizzling, fiery death in Earth's upper atmosphere.



Looking east 2 A.M., April 22

Meteor enthusiasts look forward to the Lyrids. It is the first major shower since early January's Quadrantids, and it's nicer to observe at this time of year. April skies are warmer and, for the most part, insect free.

The shower's maximum occurs at 16 UT (noon PST) on April 22, so North Americans should watch during the early morning hours before sunrise on April 22.

Once the first-quarter moon sets (around 1:30 A.M.), sky conditions will favor spotting these modestly swift meteors. Roughly 15 meteors an hour should be visible, although records show that the average count can rise to above 60. Most Lyrids are faint, and some produce long-lasting trains, but you'll have a long wait between them. The Lyrids will be a trickle compared to last November's Leonids.

By the Dusk's Late Light

Spring is the best time to spot the zodiacal light. This faint haze is caused by sunlight scattering back to Earth from microscopic space dust. It is easily recognized once you learn how to identify it.

The tiny particles generally orbit in the plane of the solar system, and like the planets, they lie along the ecliptic. Once the deep blue of ordinary twilight has disappeared, the zodiacal light takes the form of a large, pale-gray pyramid with a rounded peak on the ecliptic some 30° above the horizon.

You'll need dark skies to see this naked-eye object. A dark-sky site will also show the contrast between its faint glow and the background sky. The zodiacal light is often brighter than the winter Milky Way through the constellations Cassiopeia and Auriga.

To be absolutely sure you are seeing the zodiacal light and not the last remnants of twilight, wait until the sun is 18° below the horizon. This point in time is called the end of astronomical twilight, and is precisely given in most astronomical software packages as well as observing handbooks. The end of astronomical twilight is roughly two hours after sunset for mid-northern latitudes.

Jerry Schad

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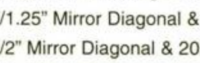

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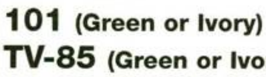

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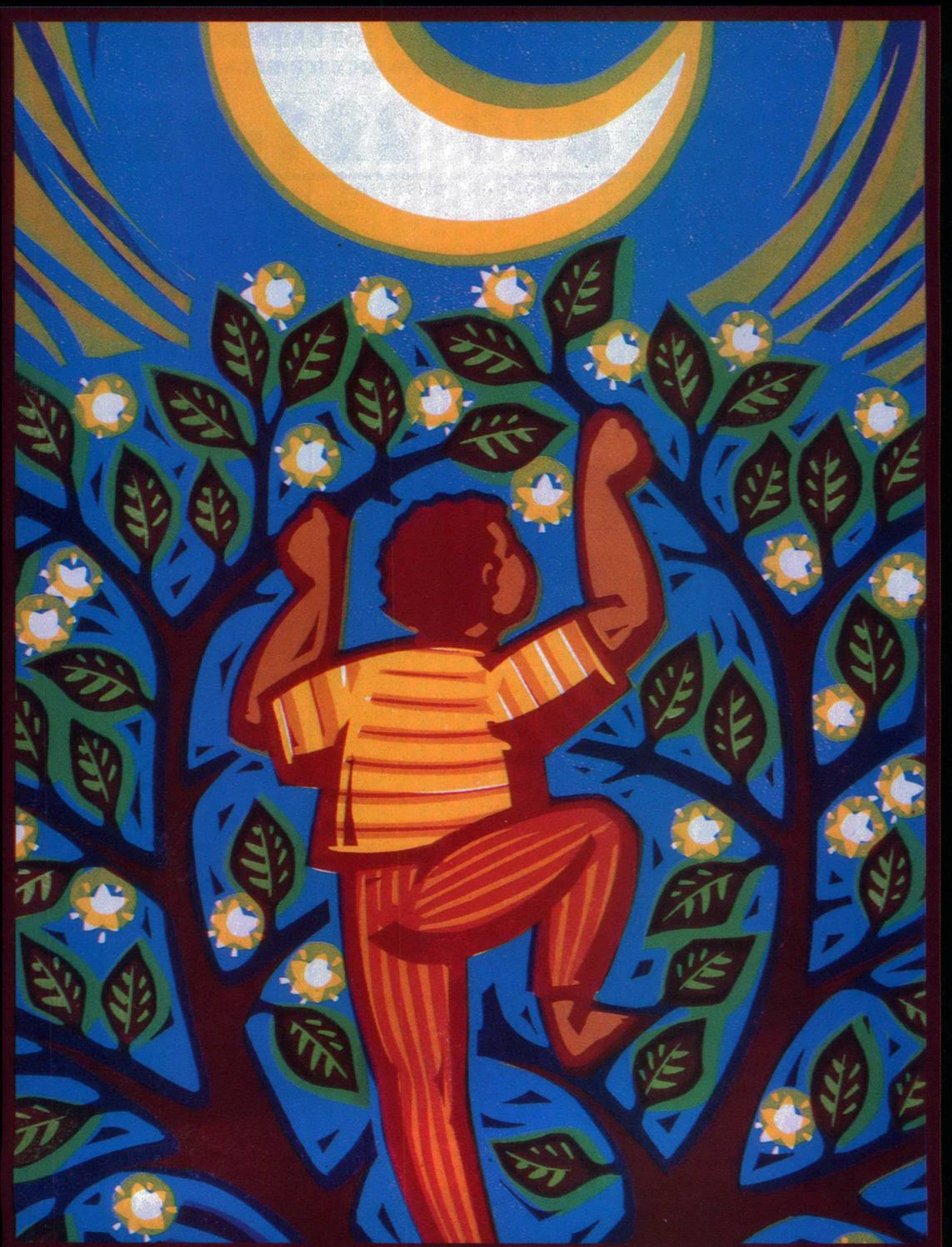


Kids' Corner

It's Just a PHASE

Use the moon's changing face to teach a lesson in astronomy.

by Jeanette Brown

"Mommy, the moon ball is following us." I was two, bundled up in the backseat of a car, craning my neck to peer out at the dark sky and the bright moon, which did indeed seem to go wherever we went. I would be willing to wager that the toddler who thought the "moon ball" was following her and her mom hadn't yet looked up to see that moon ball as just a sliver. . . . As I grew older, the moon's changing phase became harder to miss — I stopped calling it the moon ball and began to wonder just what I was seeing.

Because the moon is the easiest object to find in the night sky, most children spot it without difficulty. So, what do you say when your child begins to notice the moon's changing phases and demands an explanation? You'll do best to base it on the simple facts: The moon produces no light of its own — the light we see is reflected sunlight. As the moon circles our planet, once a month, the angle formed by the sun, Earth, and moon changes. It's this change that produces the beautiful phases we see from Earth. New moon, first quarter, full moon, and last quarter are the four primary phases. Waxing crescent, waxing gibbous, waning gibbous, and waning crescent are the intermediate phases. Does it sound confusing? It doesn't have to be.

Margaret Chodos-Irvine

Picture the scene in terms of a clock whose hands are moving backward. In this imaginary world, the moon rests on the clock's hour hand, Earth sits at the clock's center, while the sun shines far off in the direction of 12 o'clock. As the moon orbits counterclockwise around Earth, its position relative to the sun and Earth changes, giving us the phases.

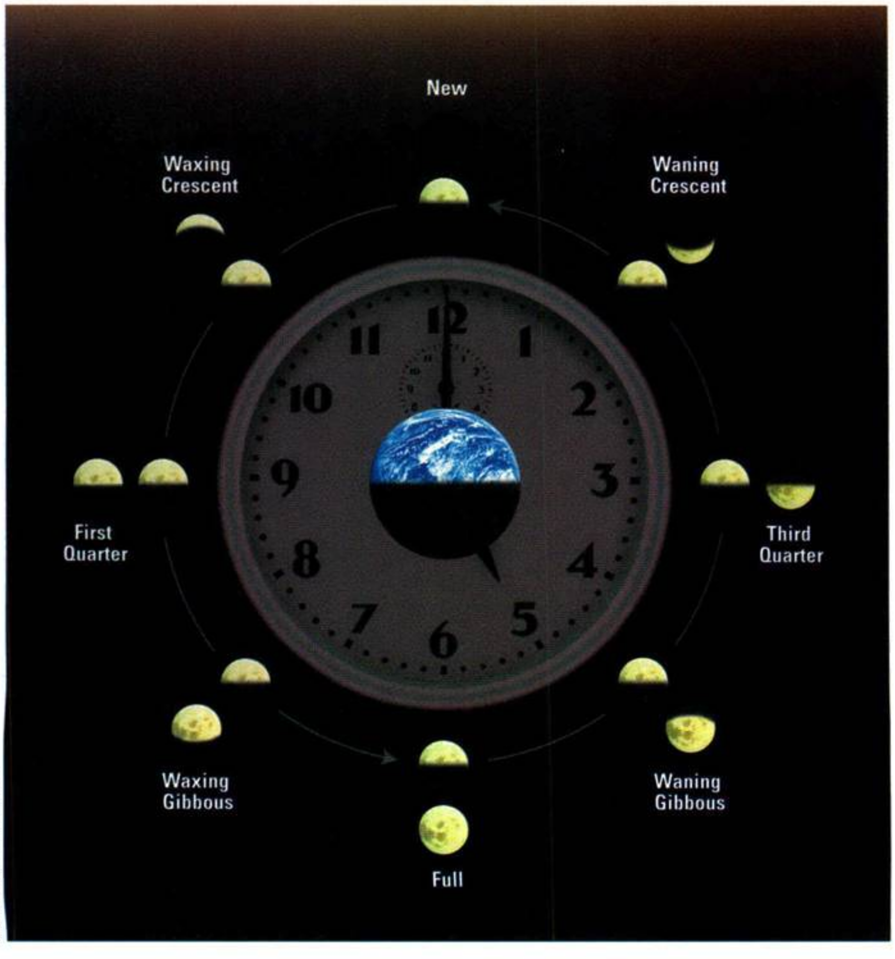
The first phase in the lunar cycle is new moon. At this point in its orbit, the moon is positioned between the sun and Earth at 12 o'clock. From Earth, the sun and moon appear to be in the same part of the sky and will rise and set together. The side of the moon that receives the sun's light is facing away from Earth, so no moon is visible.

One day after new moon, a faint sliver can be seen low on the western horizon at sunset. The phase has moved from new to a waxing crescent. As the moon continues in its counterclockwise orbit, the crescent grows larger, or waxes. One week later, the moon reaches its second primary phase, first quarter. Accordingly, the moon has moved one quarter of the way around Earth.

At first quarter, the moon sits at 9 o'clock. The sun, Earth, and moon form a right triangle, and half of the moon's disk is illuminated. At first quarter, the moon rises 6 hours after the sun — at about noon. It reaches its highest point at sundown and sets around midnight. That means the moon can be seen during daylight hours in the afternoon.

For several days after first quarter, the moon continues to wax but is a waxing gibbous phase instead of a waxing crescent. A gibbous moon is more than a quarter moon but less than a full moon. During this phase, the moon moves from 9 o'clock to 6 o'clock on the dial, and the sun-Earth-moon angle is getting larger — just like the moon's phase.

When the moon reaches its 6 o'clock position, the phase is full. The side of the moon that faces Earth is fully illuminated — that large circle of light a certain two-year-old child called the moon ball. On the clock, the sun, Earth, and moon form a straight line. From Earth, the sun and moon appear to be at opposite ends of the sky. So as the sun sets, the moon rises. The big moon ball is visible all night.



As the moon orbits Earth (the inner circle) its position relative to the sun and Earth changes causing the lunar phases (the outer circle) we see in our sky.

Astronomy: Elisabeth Rowan

Once it's past full, the moon moves from 6 o'clock to 3 o'clock and the sun-Earth-moon angle begins to shrink. The moon's phase is also getting smaller. It's moving from waning gibbous to its third- or last-quarter phase. A third-quarter moon sits at 3 o'clock on the phase dial, where the sun-Earth-moon angle is once again 90°. From Earth, we see half of the moon's disk illuminated — the side opposite as the one illuminated at first quarter. A third-quarter moon rises about six hours after the sun sets, reaches its highest point in the southern sky at dawn, and sets at about noon.

In the week after third quarter, the moon moves through its waning crescent phase and eventually returns to new where the cycle begins again. So, there are the facts. And your two-year-old may be precocious enough to understand the concept right off the bat. My very proud momma swears that I would have been.

Precocious or not, two years old or twelve, your child (or class) stands a much better chance of understanding if you show rather than tell. Here are a couple of activities to teach the moon's phases in a hands-on way that won't be hard to grasp. They allow an individual to discover the moon's phases and the physical process that determines them.

Let's start with an easy, no-frills activity that develops observational and record-keeping skills. For each child, you'll need nothing more than a pencil, a large one-month calendar, and a firm writing surface. In advance, draw a circle in each day's square on the calendar. During the activity, kids will fill in these circles to correspond to the moon's shape on each successive day. Teachers in particular will want to begin the activity during a first-quarter phase, when the moon is visible in the afternoon sky. This way, students can develop their skills during school hours and put them to use at home later in the cycle, when the moon is in the night sky.

When you've determined a good day to begin the activity, take the kids outside and distribute materials. One tip: It helps to give the calendar an official-sounding name, something like "Lunar Observation Chart." Doing

FUN FACTS

- **At full moon, look for the rabbit, lady's profile, or the surprised man's face that are created by the bright lunar highlands and dark seas called maria.**
- **The moon's gravity is one-sixth the gravity of Earth. That means an object weighing 60 pounds on Earth only weighs 10 pounds on the moon. How much would you weigh?**
- **Because the moon rotates on its axis at nearly the same rate that it orbits around Earth, the same side of the moon always faces Earth.**
- **If you lived on the moon, Earth would go through phases. Can you figure out what those phases would be?**
- **The moon is 1.5 times larger than Pluto and 1.4 times smaller than Mercury.**
- **During the six Apollo moon landings, 842 pounds of moon rock and soil were collected and returned to Earth.**
- **The moon may have six billion metric tons of water ice at its poles: that's the weight of 200,000 Empire State Buildings.**
- **Did you know that the full moon of each month has its own name?**

January: wolf, old, or after yule moon
February: snow or hunger moon
March: sap, crow, worm, or lenten moon
April: grass, pine, frog,or egg moon
May: planting, flower, or milk moon
June: rose or strawberry moon
July: thunder, hay, or buck moon
August: green corn, sturgeon, or grain moon
September: harvest or fruit moon
October: hunter's moon
November: beaver or frost moon
December: before yule, cold, or long night moon

so will serve to make the kids feel excited and important while reminding them that they are performing a scientific observation.

With charts and pencils in hand, head outside and locate the moon. Record the date and time and shade in the day's circle to correspond with the moon's phase. As more of the chart is completed, you can explain the names for the various phases and encourage kids to add them on the appropriate days.

Activity two puts the moon on a stick. This activity is designed to show why the moon has phases. Again, the materials are few and inexpensive, and the activity is well suited for either a single child or an entire class.

First, gather your materials. You'll need a clear 100-watt light bulb, either a lamp stand with its shade removed or a light clamp, a large room that can be darkened for the demonstration, pictures of the moon at its four primary phases (the Lunar Observation Chart will also work), and one Styrofoam ball and one sharpened pencil per child.

As classroom pencils are no longer made of lead, poisoning is not really a concern. But injury is, so you may want to push the balls onto the pencils yourself, rather than assigning that task to the kids. That done, place the light in the center of the room and have the children stand in a circle around it (again, this works just fine with one child too). Distribute a "moon on a stick" to each child, darken the room, and instruct the children to hold their moons above their heads so that the side of the ball facing them is in shadow. That is, the ball is between the child and the light source.

Explain to the children that the ball is the moon, the light is the sun, and the child's head is the Earth. Then have them turn slowly counterclockwise, stopping every quarter turn to observe the shadow on the ball. By consulting their charts or the pictures you provide, each child should be able to identify the various moon phases as modeled on the Styrofoam balls.

Begin slowly, starting with the primary phases and check to see that everyone is catching on. Once they comprehend the basic process, have a little more fun with it. Call out a phase and see who can find the position in the "moon's" orbit where that phase is visible. Or up the ante a little and ask to see a gibbous moon or a crescent moon. You could even have them circle around crooning "waaaaxing" until suddenly they pass full and the cry changes to "waaaaaning." Just don't let them get too dizzy . . . or have a supply of paper bags on hand as well! A

Jeanette Brown is a graduate student at NYU and Astronomy's *former copy editor. Her most recent article was "Gifts for Budding Astronomers," December 1998.*

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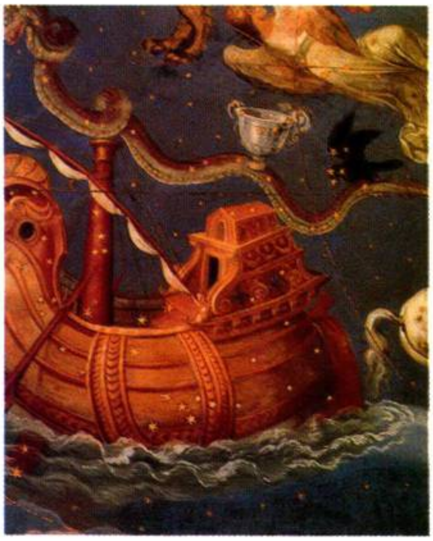
Vela and Carina



The winter Milky Way comes alive in the Sails and Keel of the great ship Argo.

by Tom Polakis

WHO CAN BLAME observers confined to northern latitudes for feeling they are missing out on many of the sky's wonders? Accustomed to seeing the Milky Way end below Canis Major, they can only imagine what lies beyond the horizon. But for anyone living in or visiting the southern United States or, even better, points farther south, don't pass on the chance to view the sky on the "other side." One of the best places to start exploring in this region is the magnificent constellations Vela and Carina.

Vela, the Sails of the legendary ship Argo, contains a couple dozen stars brighter than 5th magnitude yet surprisingly has a form that's difficult to trace. The galactic equator cuts right through the heart of the constellation, making it a place rich in star clusters and nebulae.

Carina, the Ship's Keel, is a sprawling mass of stars that also lies in the plane of our galaxy and contains Milky Way treats. Observers in the southern United States should be familiar with Alpha (α) Carinae, also known as Canopus. At magnitude –0.7, Canopus ranks as the sky's second-brightest star, after Sirius. Unfortunately for mid-northern observers, it never really emerges from the horizon soup. Unlike Sirius, Canopus is truly luminous — it shines with the light of some 10,000 suns from a distance of 300 light-years.

Both Carina and Vela once joined with their neighboring constellations Puppis and Pyxis to form the huge, now obsolete constellation Argo Navis, The Ship of the Argonauts. This single, unwieldy constellation was divided into four by Nicolas Louis de Lacaille in the 18th century. However, the Greek letter designations remained as they were in the good ship Argo, so Vela finds itself with neither an Alpha nor Beta (β) star.

The most recognizable pattern in this part of the sky is the False Cross, which consists of four 2nd-magnitude stars: Kappa (κ) and Delta (δ) Velorum and Epsilon (ε) and Iota (ι) Carinae. This asterism is a scaled-up version of the real cross found in the constellation Crux, which lies 25° to the east.

Starting at the False Cross, it's just a short sweep west to the open star cluster **NGC 2516**. Visible to the unaided eye as a faint mist against a starry backdrop, through binoculars the cluster resolves into several dozen bright stars spanning nearly a degree. A rich-field telescope provides the most pleasing image, revealing more than a hundred stars down to magnitude 13. Note the many double stars, including a close pair of similarly bright stars near the cluster's center.

Some 14° north of NGC 2516 lies the double star **Gamma (γ) Velorum**. The primary component is the brightest Wolf-Rayet star in the sky and one of the hottest stars known, with a surface temperature exceeding 50,000° F. These stars possess incredibly strong stellar winds that blow their gaseous outer layers into the surrounding interstellar material at a speed of more than 1,000 miles a second. Although both component stars have naked-eye brightness, they are separated by less than an arcminute and a bit too close for even the keenest eyes to split. The pair can be resolved in a small telescope or even steadily held 7x50 binoculars. Owners of larger scopes may want to go after the fainter components of this five-star system.

From Gamma Velorum, take an easy 2° sweep southward to the fine open cluster **NGC 2547**, which lies

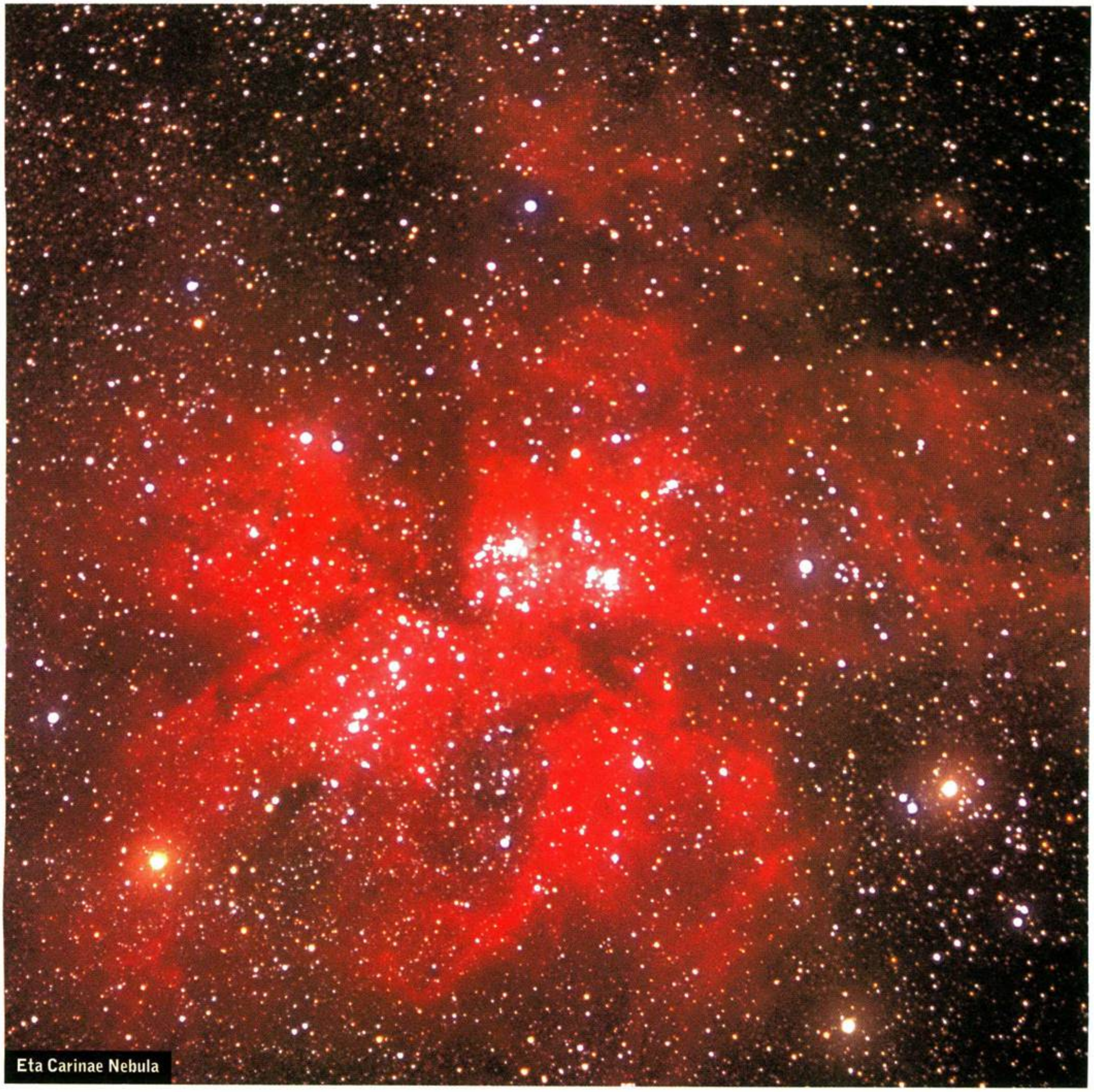
Jerry Lodriguss and John Martinez

1,300 light-years from Earth. In a 6-inch telescope, NGC 2547 appears as a cluster of scattered stars of differing brightness that fills a half-degree field. With the faintest cluster members glowing around magnitude 13, a modest scope shows all the stars and no haze from unresolved background stars. Although the 6.5-magnitude star located at the center seems almost too bright to be a member, it does belong to the cluster.

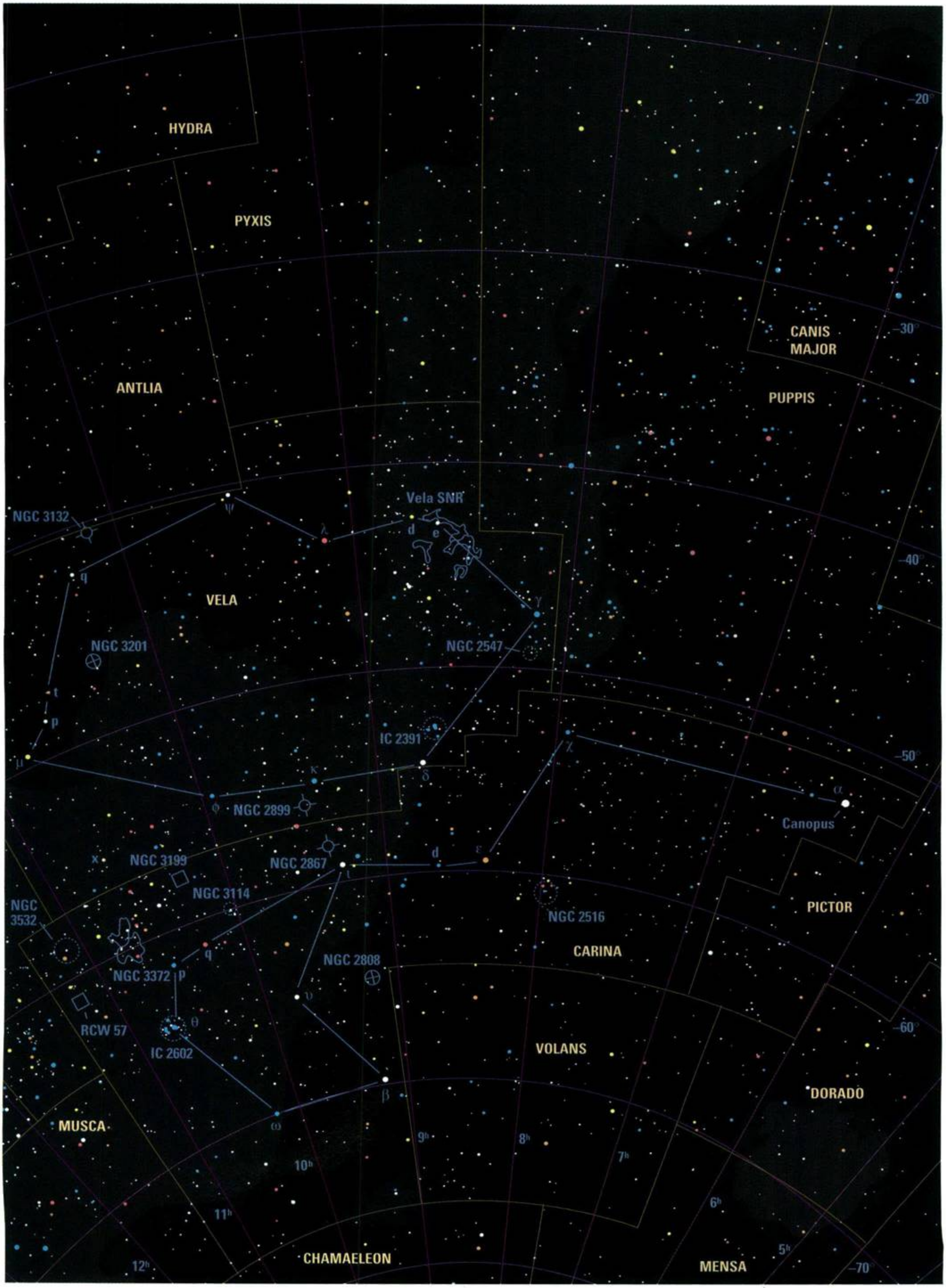
In some ways, the **Vela Supernova Remnant** is the southern sky's answer to the Veil Nebula in Cygnus. Located some 1,500 light-years away and covering 5° of sky, it ranks as the largest supernova remnant in the sky. Roughly 12,000 years ago, a massive star exploded at this site. Today we see the gas in the collision zone between the material ejected by that star and the interstellar gas it has swept up, glowing as it is heated by shock fronts from the expanding shell. Many sources, including the *Uranometria 2000.0* star atlas, incorrectly label this as the Gum Nebula, which is in fact a huge, overlapping emission nebula centered in Puppis.

A 13-inch telescope with a nebula filter gives an astonishing view of this supernova remnant, with strings of nebulosity lacing field after field. Look to the west of the 4th-magnitude star e Velorum for one of the brightest of these strands, elongated north-south and filling a 1° field. Surprisingly, only one portion of this immense, beautiful complex earned a place in the NGC. Some 5° east-southeast of the remnant's center lies NGC 2736, which appears for all the world like the Veil Nebula near 52 Cygni — a twisted, writhing cigarette-smoke plume more than half a degree long.

Return now to Delta Velorum and scan 2° north-northwest to find the



Eta Carinae Nebula


-20°
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8h
7h
10h
11h
6h
12h
CHAMAELEON
MENSA
5h
-70°

The Ship

> *"Would that the Argo had never winged its way to the land of Colchis through the dark-blue Symplegades! Would that the pine trees had never been felled in the glens of Mount Pelion and furnished oars for the hands of the heroes who at Pelias' command set forth in quest of the Golden Fleece!"*
>
> Medea
>
> — *Euripides (484? – 406? B.C.)*

Euripides wrote of the Argo Navis (or Swift Ship), the first Greek vessel built to sail the open ocean. The ship is most famous for carrying Jason and the Argonauts (the "mariners of the Argo" that included, in some versions at least, Hercules, Theseus, Orpheus, and Nestor) on their legendary search for the Golden Fleece.

This quest began as a result of Jason's attempt to regain his father's throne. When Jason was a boy, his father, King Aeson, grew weary of the monarchy. He passed the crown to his brother, Pelias, with one condition: When Jason came of age, Pelias had to return the crown to him. Time passed and Jason grew. When he went to Pelias to reclaim his royal legacy, Pelias feigned a willingness to abdicate and suggested a great adventure before Jason assumed the duties of king.

The boy delighted at the idea, and called upon Argus to build the massive ship. Athena, goddess of knowledge and skill, helped by giving Argus the ability to complete his task. She also provided a sacred oak timber from the forest surrounding the oracle of Zeus at Dodona. Possessed of magical powers, this plank could speak and see the future. It was placed at the ship's prow and formed the figurehead.

One of the many dangers the Argonauts faced were the Symplegades, or Clashing Rocks, that guarded the entrance to the Black Sea. To guide their way, the sailors released a dove. As the bird flew ahead, the rocks came together and clipped its tail feathers. As the rocks recoiled, the route was clear for a brief moment. With hard rowing by the Argonauts and a push from Athena, the Argo barely slipped through the strait, suffering only minor damage to its stern.

Stories of great ships can be found in several ancient cultures. In Egyptian mythology, for example, this region of sky represented the ark that carried Isis and Osirius to safety during the deluge. — *Andrea Gianopoulos*

Deep-Sky Objects in Vela and Carina

Object	R. A. (2000.0)	Dec.	Mag.	Size/Sep.	Type	Notes
NGC 2516	7h58.3m	–60°52'	3.8	30'	OC	
Gamma Vel	8h09.5m	–47°20'	1.9/4.2	41.2"	Dbl	
NGC 2547	8h10.7m	–49°16'	4.7	74'	OC	
Vela SNR	8h34.2m	–45°45'	—	5°	SNR	Supernova remnant
IC 2391	8h40.2m	–53°04'	2.5	50'	OC	
NGC 2808	9h12.0m	–64°52'	6.3	13.8'	GC	
NGC 2867	9h21.4m	–58°19'	9.7	11"	PN	
NGC 2899	9h27.0m	–56°06'	11.8	120"	PN	
NGC 3114	10h02.7m	–60°07'	4.2	35'	OC	
NGC 3132	10h07.7m	–40°26'	9.7	30"	PN	Eight Burst Nebula
NGC 3199	10h17.1m	–57°55'	—	20' by 15'	BN	
NGC 3201	10h17.6m	–46°25'	6.8	18.2'	GC	
x Vel	10h39.3m	–55°36'	4.4/6.6	52"	Dbl	
IC 2602	10h43.2m	–64°24'	1.9	50'	OC	Southern Pleiades
NGC 3372	10h43.8m	–59°52'	3	2°	BN	Eta Carinae Nebula
NGC 3532	11h06.4m	–58°40'	3.0	55'	OC	
RCW 57	11h12.0m	–61°12'	—	50' by 25'	BN	

Object: Designation in NGC or other catalog. **R.A. (2000.0) and Dec.:** Right ascension and declination in epoch 2000.0 coordinates. **Mag.:** Visual magnitude. **Size/Sep.:** Size in degrees, arcminutes, or arcseconds, separation in arcseconds.

naked-eye open cluster **IC 2391**. This sparse, nearby cluster lies approximately 500 light-years away. Only 30 stars shine brighter than 12th magnitude, but the main attraction is the handful of naked-eye stars that make this a good binocular target. Using 11x80 binoculars, IC 2391 displays six bright stars and another 13 stars down to magnitude 9.5 but with no obvious border. A telescope overwhelms this cluster, spreading its member stars too far apart.

Just over 1° southeast of Kappa Velorum, the star at the tip of the False Cross, is the bipolar planetary nebula **NGC 2899**. A 12-inch telescope shows two bright lobes, each round and about 30" across, connected by a bar traversing the center. Larger telescopes may show a fainter envelope that brings the size of the planetary up to 2'. Immersed in a rich part of the Milky Way at a distance of 2,800 light-years, the field surrounding NGC 2899 appears magnificently starry. Don't expect to ferret out a central star though — it hasn't been seen optically yet, even with professional telescopes. Some astronomers think that the responsible star may be hiding behind a binary companion.

Two degrees south-southwest of NGC 2899 and back in Carina lies another interesting planetary, **NGC 2867**. When John Herschel discovered this object with his 18-inch telescope, he at first suspected it might be a planet. He confirmed it lay far beyond our solar system by measuring its position relative to the nearby stars on successive nights and detecting no motion. The better optical quality of today's telescopes reveals the planetary's tiny annular disk that has a subtle north-south elongation.

Luke Dodd

Nearly 6° south of Iota Carinae and near the border with Volans dwells the impressive globular cluster **NGC 2808**. A 4-inch telescope barely shows its brightest stars, but the cluster springs to life with innumerable 13th- and 14th-magnitude jewels using 8 inches of aperture. Well concentrated to a sharp center, the cluster presents several hundred stars in an area about 10' across. Radiating streamers appear to bring the overall size to 15'. Many observers rank NGC 2808 as the third-best globular cluster in the southern sky, trailing only Omega Centauri and 47 Tucanae, and among the five most beautiful in the entire sky.

Vela Supernova Remnant

Luke Dodd

Some 8° northeast of this globular, in a portion of the Milky Way rich in competing open clusters, resides one of the most spectacular. **NGC 3114** appears as a mist against an already bright background when seen with the unaided eye from a dark site. But turn an instrument that provides a 1° or larger field of view on it and you will be truly impressed. A 4-inch telescope at 30x shows more than a hundred stars scattered about with no distinct center. In a 10-inch scope at 75x, it is difficult to contain the cluster's 200 members brighter than 15th magnitude. At a distance of 2,800 light-years and an apparent size of 35', NGC 3114 extends some 30 light-years across.

Writing in the European journal *Astronomy & Astrophysics*, J. E. Dyson and J. Ghanbari describe **NGC 3199** as "an interstellar snow plough." Lying 3° northeast of NGC 3114, this nebula appears similar to the Bubble Nebula in Cassiopeia and the Crescent Nebula in Cygnus. Its distorted shape arises from a strong stellar wind blowing off a Wolf-Rayet star. A small telescope equipped with a nebula filter reveals the crescent shape of the nebula, which opens to the east and appears brightest at the south end. The eastern edge appears sharp while the western edge is diffuse throughout. A small trio of faint stars lies at the "focus" of the arc.

Heading south once again, to a point 6° southeast of NGC 3114, brings us to an open cluster sometimes referred to as the "Southern Pleiades." Centered on the 3rd-magnitude star Theta (θ) Carinae, **IC 2602** is a wonderful assemblage of a half-dozen stars visible to the naked eye covering a 1° area. In an 8-inch telescope at 50x, IC 2602 shows 30 stars with no discernible boundary. Sweep less than a degree south to find the much fainter and smaller open cluster, Melotte 101.

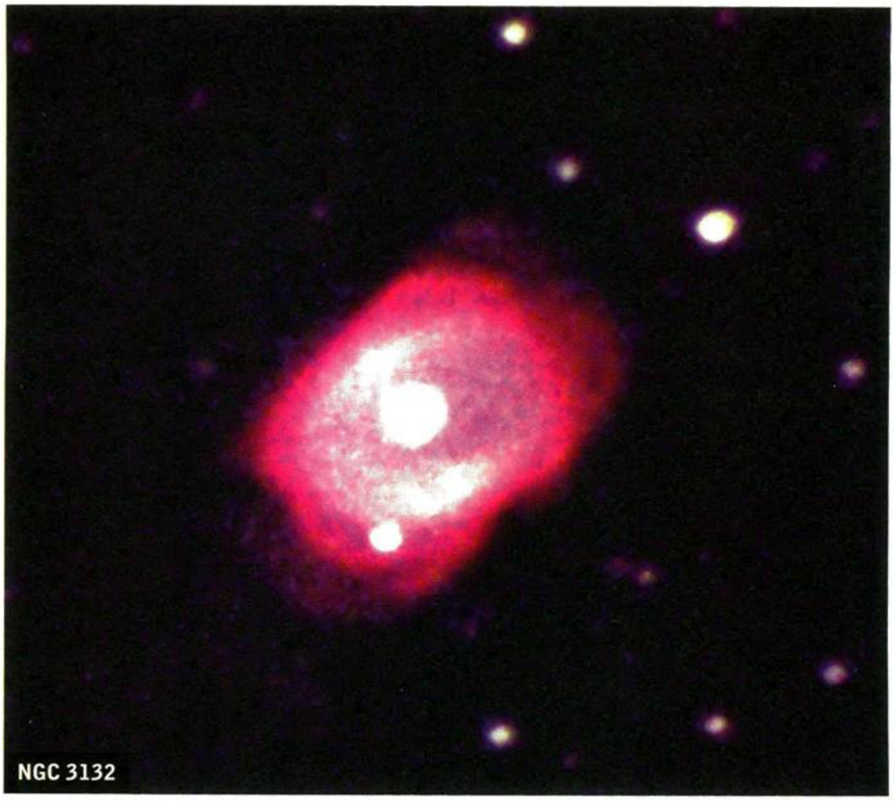
Perhaps the highlight of this entire region is the **Eta (η) Carinae Nebula** (NGC 3372). Located 5° due north of IC 2602 and spanning 2°, it ranks as the brightest emission nebula in the sky. It is a spectacular object whatever instrument you use. It appears as the brightest spot in the Milky Way to the naked eye — clearly a large, nebulous glow. Binoculars bring out its full extent and hint at the object's enormous dust lanes. Through a telescope at 40x, the most prominent detail is this dark, V-shaped rift slicing through the nebula's center. You can see scalloped detail where this edge meets the bright nebulosity, and the entire object is mottled with filaments of gas that a nebula filter will greatly enhance.

It pays to treat this object with reverence by very slowly increasing the magnification of your view. If you peer into the center of NGC 3372 at 100x you will see the Keyhole Nebula, a dark cloud with overlying nebulosity. Even the highest magnifications hold something of interest: the star Eta Carinae itself. A region of yellow nebulosity surrounds Eta Carinae, which has earned it the nickname "the Fried Egg." This central blaze is more commonly known as the Homunculus, or Little Man. Under the steadiest seeing conditions, tiny spokes can be seen extending from the star.

A century-and-a-half ago, Eta Carinae was the sky's second-brightest star, exceeding even Canopus. Since then it has varied irregularly and today glows at 6th magnitude, partially because the surrounding nebula obscures it. In fact, it is one of the most massive and most luminous stars in the entire galaxy, shining with the light of over 5 million suns.

From Eta Carinae it is only a 3° sweep eastward to the great open cluster **NGC 3532**. Spanning a full degree, the cluster contains more than 100 stars brighter than 12th magnitude that shine across a distance of 1,600 light-years. Naked-eye viewers will notice an oval concentration brighter than the surrounding Milky Way, but optical aid brings the best view. Even 7x50 binoculars reveal 50 stars that are detached from the starry background. Through a 4-inch telescope, the central half-degree becomes packed with stars between 7th and 10th magnitude. Look for a prominent lane devoid of stars that runs along the northern edge of the cluster. Although the view in a wide-field telescope is most pleasing, a large aperture does reach the multitude of fainter members.

On the eastern edge of Carina south of NGC 3532 lies a nebulous complex known as **RCW 57**. Despite its rather obscure designation, don't pass up this interesting target. It encompasses both NGC 3603, the densest concentration of very massive stars in our galaxy, and NGC 3576, a giant emission region excited by the hot, massive stars. It compares well with the Tarantula Nebula in the Large Magellanic Cloud. Although NGC 3603 appears bright, it is too small to be resolved or even identified as an open cluster. Faint emission nebulosity can be seen surrounding the bright mass of stars at the center. To the west, the area around NGC 3576 becomes spectacular when seen in a backyard telescope. Through a nebula filter at 100x, four bright glowing regions immediately come into view accompanied by two fainter ones to their south. All this activity happens in an area scarcely 10' across.


NGC 3132

James Foster

Four degrees north of Eta Carinae, over the border and back into Vela, lies the pretty double star **x Velorum**. An easy split in binoculars, this pair shows a gorgeous contrast between orange and blue stars vaguely reminiscent of Albireo in Cygnus.

The loosely concentrated globular cluster **NGC 3201** lies about 10° north-northwest of x Velorum and actually climbs above the horizon murk when viewed from the southern United States. Only 16,000 light-years distant, close for a globular cluster, its stars glow brightly. An 8-inch telescope resolves about 100 members over an area 8' across. Larger telescopes extend the size and number of stars slightly, but the concentration remains very loose and the edge is difficult to define.

On the northern edge of Vela, where it meets with Antlia, resides the planetary nebula **NGC 3132**. Also known as the Eight Burst Nebula, the first impression of this object is a planetary with a bright central star. Indeed a 10th-magnitude beacon lies at the nebula's center. But this star isn't the one responsible for illuminating the surrounding shell. The real candidate seems to be a 15th-magnitude star that lies 2" from the bright star. NGC 3132 has a very high surface brightness, allowing you to view it at high magnification. A shell 60" by 45" in diameter surrounds the bright star. This shell dims gradually from the inner edge to the center, where patchy detail is subtly visible when the seeing permits.

These are just a few of the highlights in this impressive region. You can find dozens more simply by scanning the rich Milky Way starfields in Vela and Carina with binoculars or a small telescope. So the next time you find yourself face-to-face with the southern sky, be sure to explore the treats awaiting you in the ship of Jason and the Argonauts.

Tom Polakis is an aerospace engineer in Arizona. His favorite astronomical pursuits are deep-sky observing and photography.

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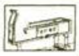

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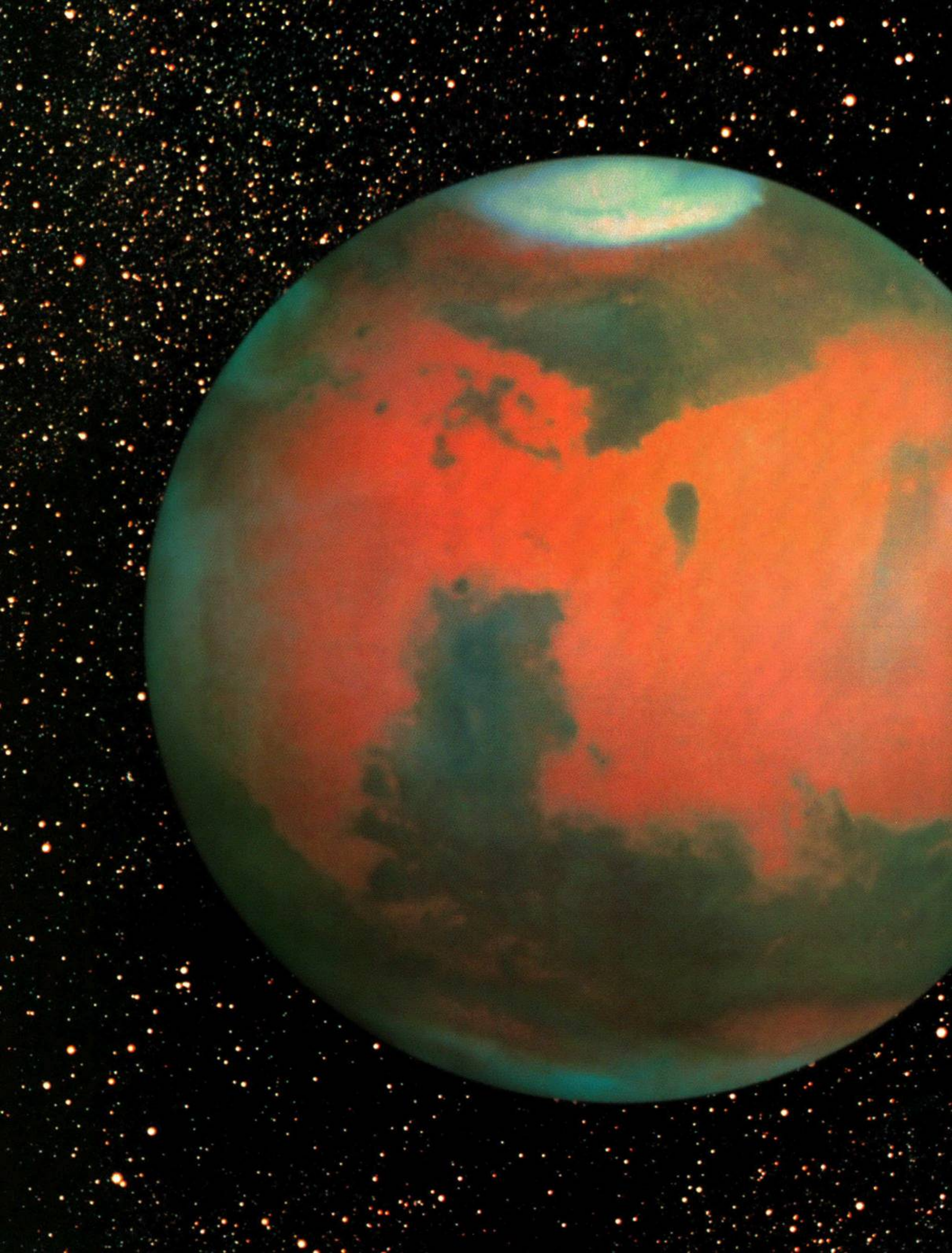


Red Planet at Night, Observer's Delight

Don your observing cap, Mars is at opposition.

by Phil Harrington

No planet has piqued our curiosity like Mars. First worshipped as the god of war, then seen as a world harboring alien life, today Mars is viewed as a place to be studied, visited, and ultimately colonized. What is it about the Red Planet that excites the imagination?

Our fascination, in part, may be due to the fact that Mars is well-placed for observation once every 26 months, when the two planets are closest. At this point, called opposition, Mars lies directly opposite the sun in our sky and the distance between Earth and Mars is at a minimum. As the gap between the two planets closes, the martian globe grows in apparent size to reveal a complex network of dim, shadowy surface features that invite scrutiny.

Some oppositions of Mars are better than others. In favorable years, when Mars reaches opposition at or near its closest point to the sun, called perihelion, the planet will be less than 35 million miles from Earth and measure about 25 arcseconds (25") across. These oppositions are called perihelic oppositions. During an aphelic opposition, Mars will be at or near its greatest distance from the sun, causing the Red Planet to be no closer than 50 to 61 million miles from Earth, and its disk will grow to only about 14" across. The last two martian oppositions (1995, 1997) were aphelic, while the most recent perihelic opposition occurred in 1988.

Our next approach to Mars is now at hand, but since 1999 is not a perihelic opposition, both our talent as observers as well as the quality of our telescopes will be put to the test. Mars reaches opposition on April 24 and is closest to Earth on May 1. On that date, it measures only 16.2" across and is 53.8 million miles away. The planet will also stay south of the celestial equator throughout the 1999 apparition, keeping it low in the sky for observers situated north of Earth's equator. Still, from mid-March through the end of June – the prime window for observing – Mars will reveal some tantalizing details.

Background photo: John Chumack/Mars: STScI

Getting the Most out of Mars

Unlike many astronomical targets, Mars does not require an exquisitely dark sky. Nor does it demand a large aperture telescope. A 4-inch telescope and a good view to the south are all that is needed to capture the martian polar caps, dark markings on the planet's surface, and even the occasional dust storm.

Because Mars will remain relatively small throughout this apparition, high magnification will be required. Even when Mars is at its closest, magnifications greater than 200x are needed to see fine details. This type of observing demands a high-quality telescope and superior eyepieces. In general, a long-focus refractor is the instrument of choice among planet watchers, followed by long-focus Newtonian and Cassegrain reflectors – both produce the highest image contrast.

In choosing an eyepiece with which to view the Red Planet, try the more conventional orthoscopics and Plössls. One eyepiece trick used by planetary observers with great success is to combine a longer focal length eyepiece with a high-quality Barlow lens. The greater eye relief of most longer focal length eyepieces means the observer can see through them more comfortably, which reduces the eye-to-brain "noise" that can block fine details.

Veteran planetary observers also recommend using color filters to enhance various features. An orange (Wratten #21) or a red (#23A or #25) filter will increase the contrast of the dark surface markings against the bright orange desert regions. Blue (#38A or #80A) and green (#58) filters are best for showing the polar caps as well as haze, fog, or clouds in the planet's thin atmosphere.

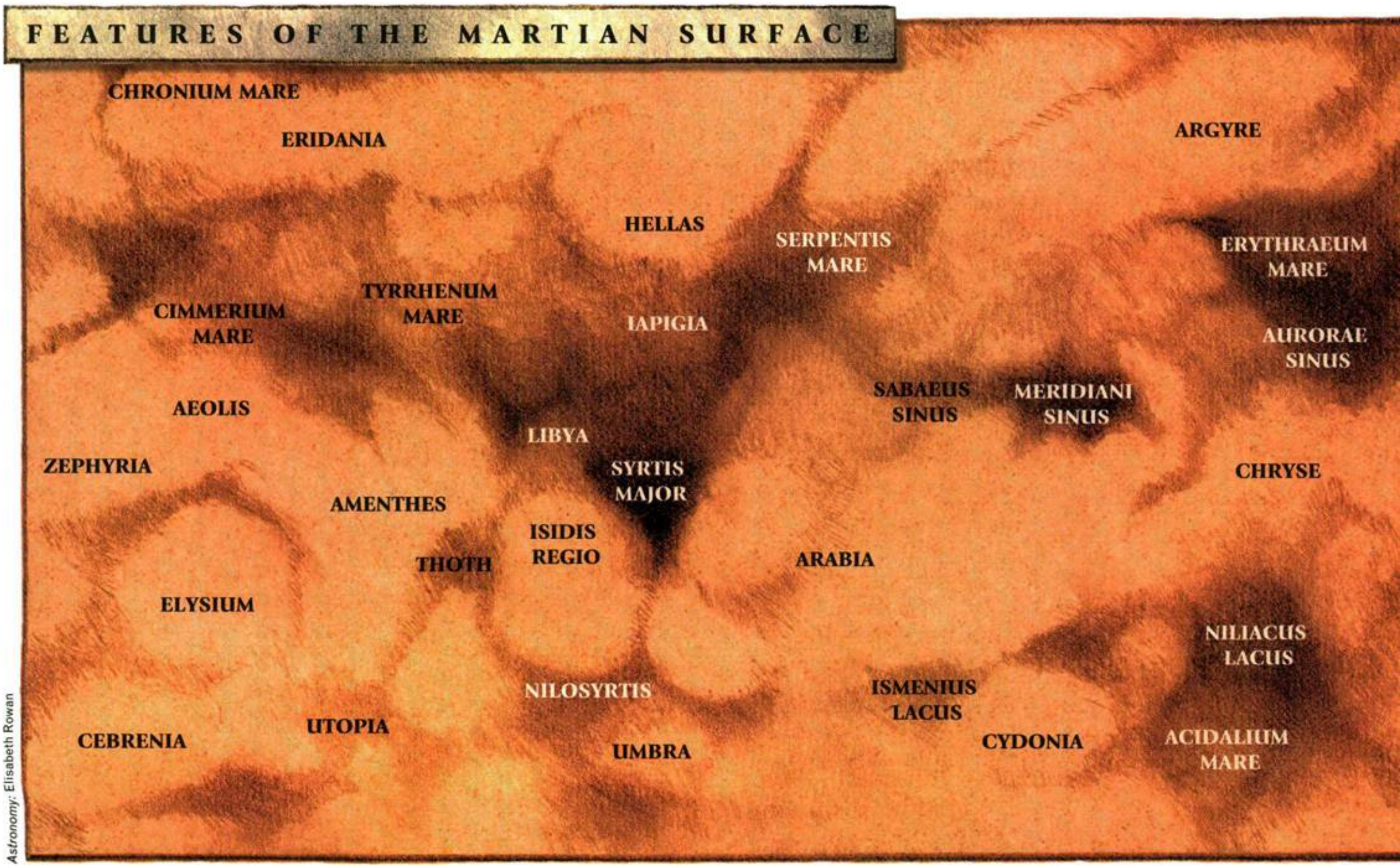
The blood-red color of Mars contrasts nicely with the stars of the Beehive Cluster (M44). Ronald E. Royer

Though they may help reveal some latent detail on the planet's surface, color filters are helpless at overcoming poor seeing conditions and inadequate optics. Mars looks its best when the air is calm and seeing conditions are steady. Judge this by looking at the stars. Are they twinkling? If so, the poor seeing may hamper your observations. On nights when conditions produce a steady atmosphere, Mars will have no choice but to reveal its secrets.

Mars: 1999

To identify specific features, remember the two "P's" of observing the Red Planet: patience and perseverance. At times Mars will appear to be a quivering blob. But on that rare occasion of atmospheric tranquillity, the planet will reward observers.

From Earth, the most prominent features are the snow-white polar caps. Over the next several months, the North Polar Cap will face Earth. As Mars approaches and passes opposition, the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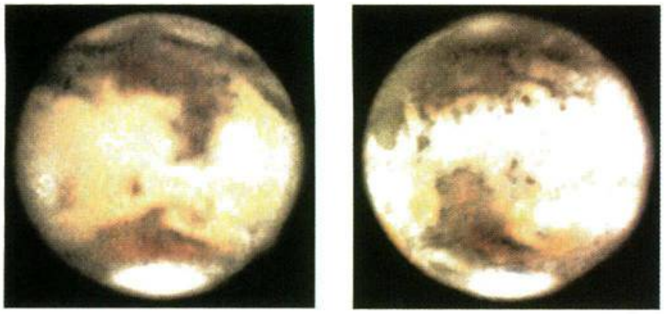
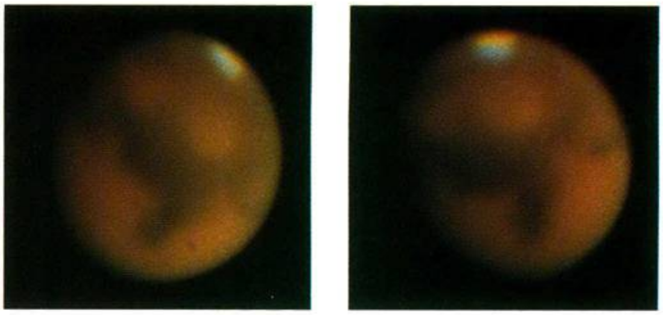


Left: The South Polar Cap with Nilosyrtis and Syrtis Major above it. Right: Niliacus Lacus, Chryse, and the Aurorae Sinus. Don Parker

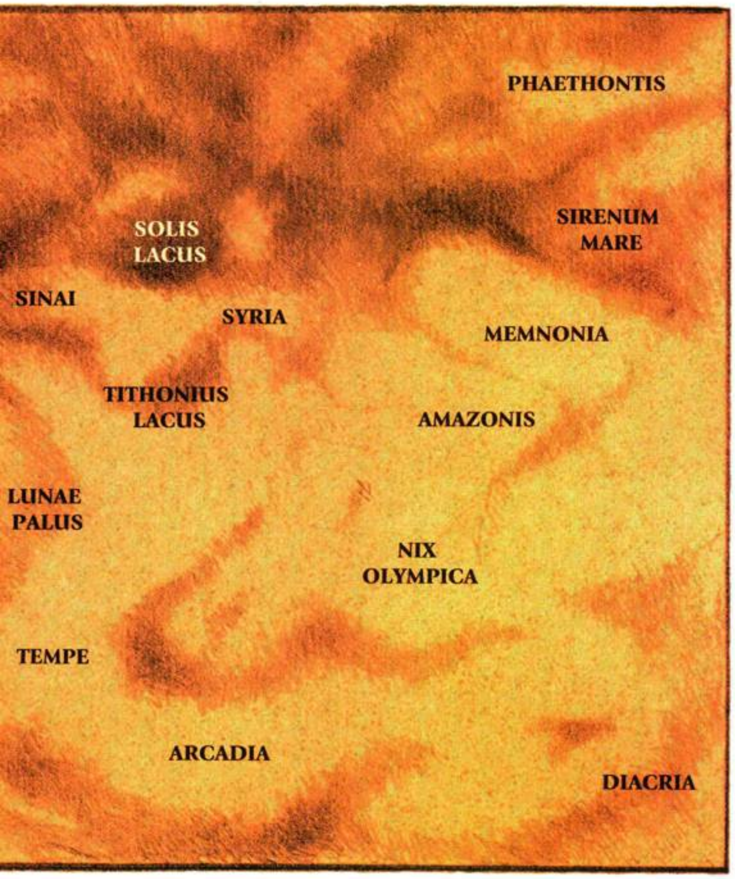


Watch the North Polar Cap shrink as Mars moves through opposition and its Northern Hemisphere moves toward summer. Don Parker

northern hemisphere shifts from late spring into summer. The thawing cap often produces complex clouds high in the martian atmosphere. These are best seen with a blue or violet filter.

Scattered across the red surface are the famed dark markings. Once thought to be lakes or regions of vegetation, these permanent features appear to change slightly in size and shape over time. It is thought that this change is due to the swirling martian winds shifting sands that alternately cover and uncover different portions of the rocky surface.

The easiest dark feature to spot is Syrtis Major, a triangular wedge that extends north-south across the planet's equator at martian longitude 240°E. Almost equally dark, but noticeably smaller, is Meridiani Sinus, a claw-shaped patch along the martian equator at longitude 0°E. Another fascinating feature appears to be watching you. Solis Lacus, the "Eye of Mars," a large, circular area at longitude 80°E, is punctuated by a dark central region.



Despite the bright evening moon at the end of April and first part of May, this is prime Mars observing time. Compare the present view with any observations made over the past few weeks. How does the polar cap compare to a month ago? Is it larger or smaller? Have any clouds formed nearby? Pay close attention to the appearance of Syrtis Major and Solis Lacus. Are they growing darker and more apparent, or becoming smaller and weaker?

Normally, surface features on Mars appear rather vague and indistinct when viewed through a telescope equipped with a blue or violet filter. Occasionally, and without apparent cause, a "blue clearing" will occur that allows the martian surface to be seen clearly for up to several days through these filters. Despite the recent scrutiny of Mars by spacecraft and the Hubble Space Telescope, the cause of blue clearings remains a mystery.

By June 25, Mars will have receded to 12" in diameter. Telescopes with apertures of 8 inches and larger will still provide views of the more apparent surface features. For smaller instruments, Mars will be a fading memory. As July turns to August, Mars will only measure 9" across as its northern hemisphere shifts from summer to autumn. Over the next several weeks, a hint of the South Polar Cap may reveal itself. During this same time period, Syrtis Major should appear to shrink as the martian winds begin to sweep sand along its edges.

A final word. Rather than casually glancing at Mars, try making systematic observations. Record the planet's appearance every chance you get. Doing so will not only reveal finer detail than is possible with a casual glance, but will also show how dynamic the features on Mars are.

If making methodical examinations of Mars appeals to you, consider joining the Association of Lunar and Planetary Observers (ALPO). With members from around the world, ALPO, along with Cornell University and NASA's Jet Propulsion Laboratory, is an important part of the International Mars Patrol (IMP). The IMP gathers and archives observations from professional and amateur astronomers to help further our knowledge of the Red Planet. For more information, contact its coordinator, Daniel M. Troiani at 629 Verona Court, Schaumburg, IL 60193, e-mail: dantroiani@earthlink.net; or visit the ALPO website at http://www.lpl.arizona.edu/~rhill/alpo/. ■

Phil Harrington is an amateur astronomer living in New York state. His last article was "Reborn Classic," March 1999. Visit Phil's home page at http://ourworld.compuserve.com/homepages/pharrington.

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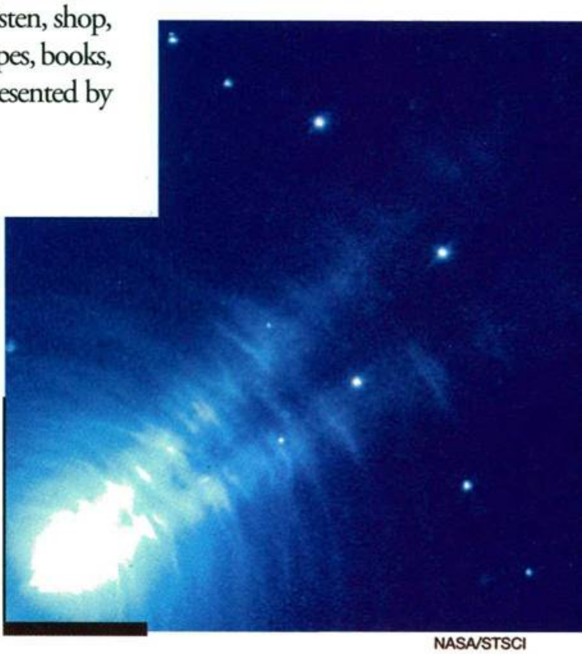
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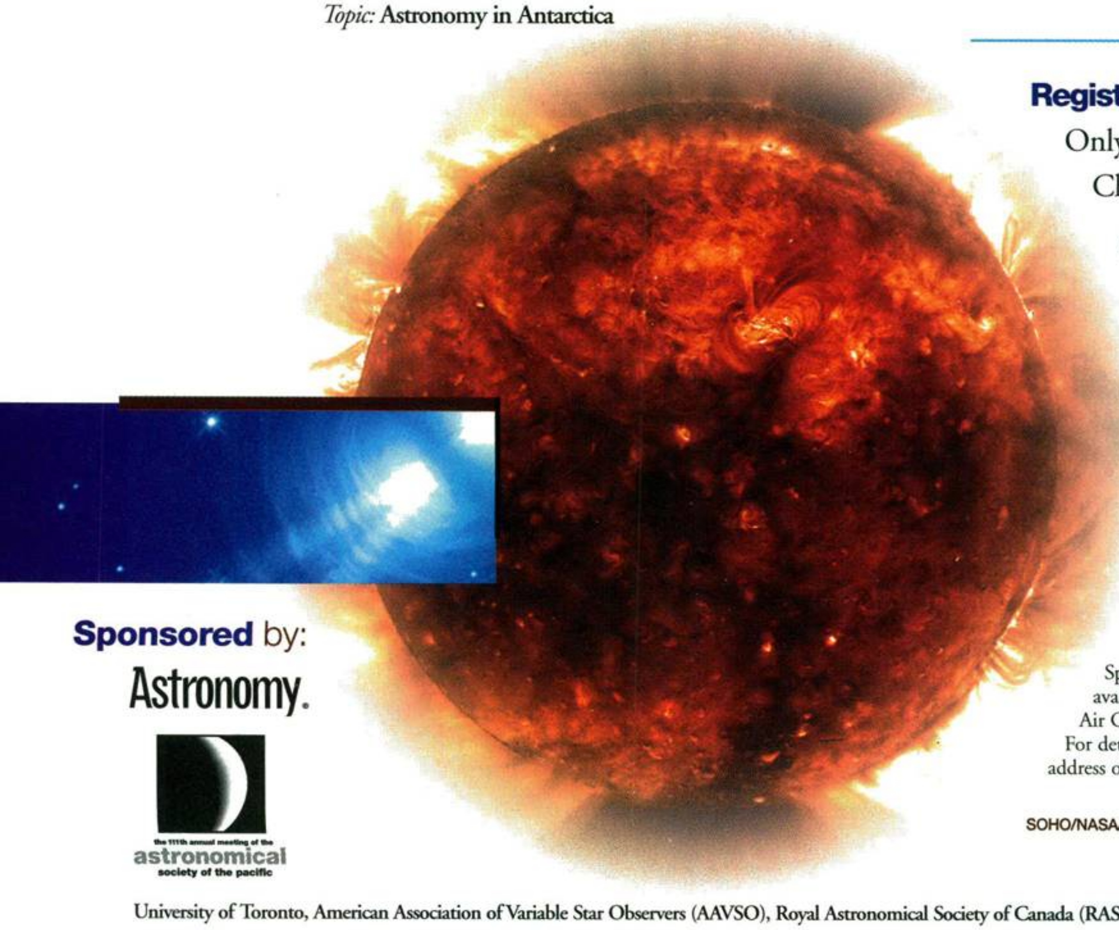
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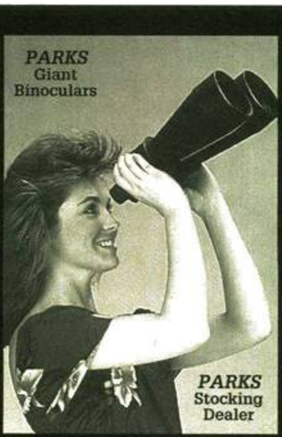
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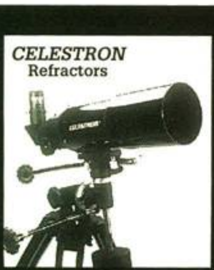
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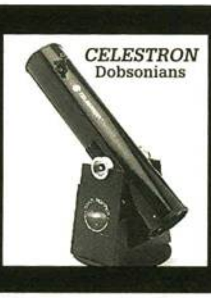
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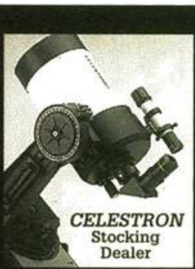
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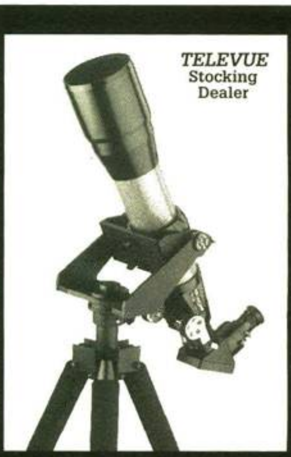
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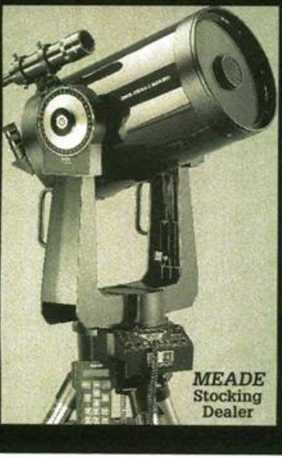
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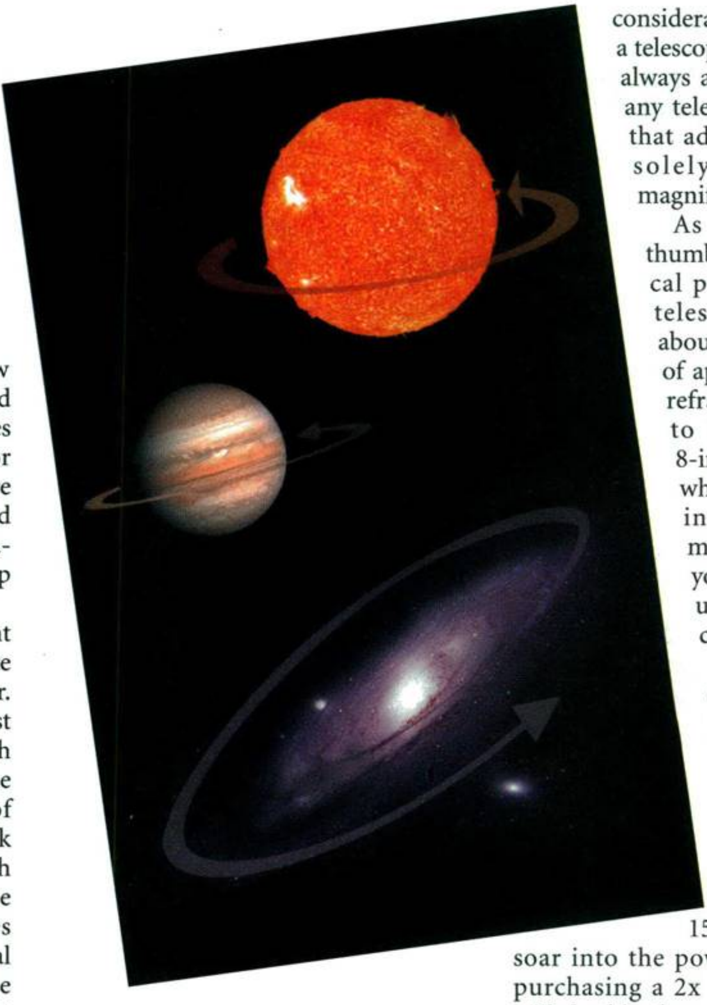
A: The question really should be how could a body *not* rotate? What would prevent it? Everything in space rotates as a result of the way it was born or because of collisions. And while there are forces in space such as gravity and magnetism that can slow down rotation, there's nothing that can stop rotation altogether.

Stars, for example, are born in giant dark molecular clouds that must rotate because they interact with one another. The stars born from these clouds must therefore also rotate, although astronomers don't fully understand the details. Planets rotate as a result of interactions that took place in the disk around the primitive sun from which they were born and as a result of the collisions that built them. Galaxies such as the Milky Way have a general rotation that is in part probably the result of the merging collisions that made them. — *James Kaler, University of Illinois*

Q: How does one determine maximum useful magnification for a particular telescope before buying a scope and/or eyepieces? — *Elvin Stingley, Reedsport, Oregon*



Planets, stars, and galaxies have at least one thing in common: They all rotate.

Astronomy: Terri Field

A: First and foremost, always remember that telescopes are rated by aperture, not power. The larger the primary lens or mirror, the more light it gathers to focus into an image. Larger scopes yield brighter images, and in this hobby brighter is better.

Any telescope, large or small, can be made to magnify at any power, making it meaningless to say a 400x scope is better than a 200x scope. So magnification alone should not be a pivotal consideration when choosing a telescope. In fact, it's almost always a good idea to avoid any telescope manufacturer that advertises its product solely on the basis of magnification.

As a general rule of thumb, the highest practical power on any given telescope works out to about 50x to 60x per inch of aperture. For a 2-inch refractor, this translates to 100x to 120x. An 8-inch tops off at 480x, while a 14-inch weighs in at just over 800x, more power than you'd ever hope to use under most sky conditions.

As for eyepieces, select a range that yields three distinct power increments. Low-power eyepieces fall between 20x and 50x; medium, 80x to 120x; and high, 150x to 200x. You can soar into the power stratosphere by purchasing a 2x Barlow lens, which will double the magnification of any eyepiece in your collection. Barlow lenses, which also come in 2.5x, 3x, and even 5x versions, are a cheap way to fill in the gaps you might have in a desired magnification sequence.

So how do you calculate magnification? First, multiply the diameter of your telescope's primary lens or mirror, measured in millimeters, by the scope's f/number. This yields the telescope's focal length. Next, divide this number by the focal length of the eyepiece in question (which is almost always printed on the barrel) to get the magnification. A telescope with a 600mm focal length paired with a 10mm eyepiece will yield a magnification of 60x. — *John Shibley*

The yellowish dust tail of Comet Hale-Bopp is created by solar photons. Bill and Sally Fletcher

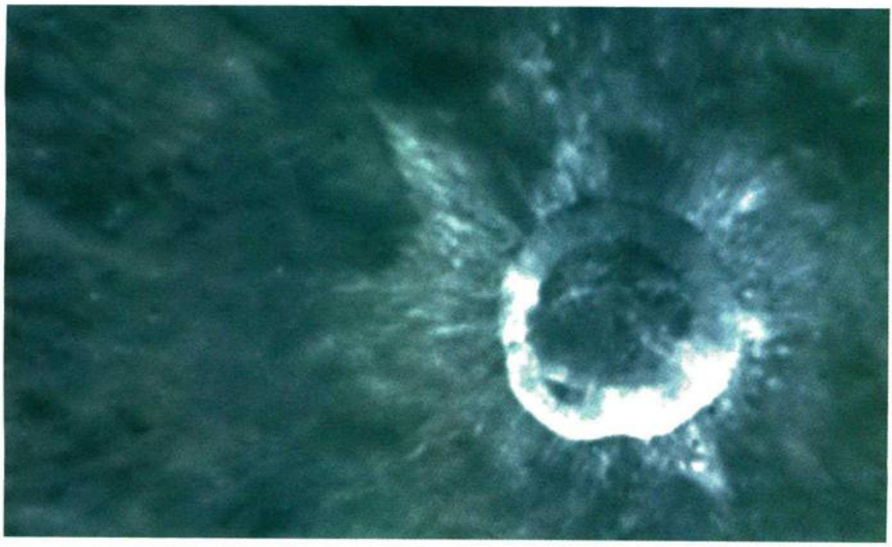
Q: Why are photons considered "massless" when they seem to interact with other particles and are curved by the gravity of stars and other objects? And if the sun emits large numbers of photons that create the dust tails of comets, this suggests that photons have momentum. How can something that has no mass have momentum? *— Maurice Lussier, High Prairie, Alberta; Norman Maillet, Ransomville, New York; and Jake Wasserman, Freehold, New Jersey*

A: Gravity used to be thought of as a force that acted over some distance to affect objects. But since Einstein's theory of general relativity, physicists suppose that space itself is bent. As an object (whether it's a planet or a photon) travels along, it follows these bends in space. Think of it this way: A bicycle will follow a dip in the road the same way an 18-wheel Mack truck will. So it doesn't matter if the object has mass or not, it's the curvature of space that tells it how to move.

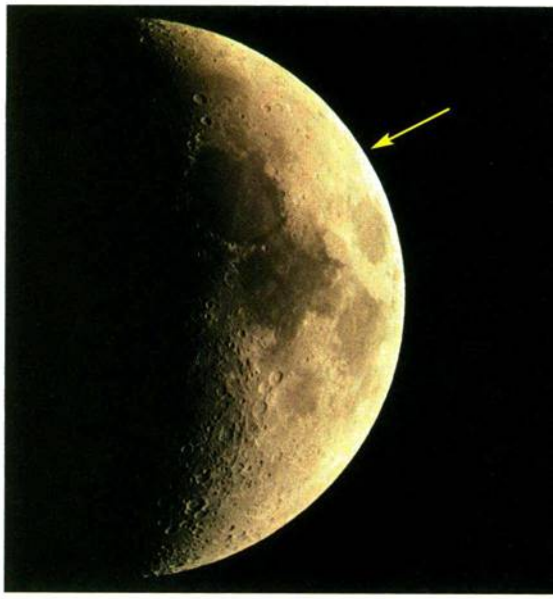
Even though photons have no mass, they still have momentum. Einstein's equation $E = mc^2$ shows that mass and energy are related. It is possible to reformulate that equation so that instead of just mass, it shows the relationship of an object's energy to its momentum. Because photons have energy, they also have momentum, even if strictly speaking their rest mass is zero. So not only do photons have momentum, more energetic photons (such as ultraviolet or x-ray photons) can have more momentum than lower energy ones (such as infrared or radio). — *Phil Plait, ACC, Inc. (check out Phil's astronomy website at http://www.badastronomy.com)*

Q: Are there any records of lunar impacts being witnessed from Earth? *— P. Edwin Letcher, Los Angeles, California*

A: There is an odd tale in a chronicle by the monk Gervase of Canterbury (in England) of strange happenings on the moon. Some science historians have interpreted his account as possibly being the record of an impact event, although it certainly hasn't been proved.



This Clementine photo shows the crater Giordano Bruno, which possibly was created during an impact witnessed by English monks in 1178. U.S. Department of Defense



The possible impact occurred just around the moon's northeastern limb (arrow). Jason Ware

On the night of June 25, 1178, Gervase says five monks saw something unusual: There was a bright young moon, and its horns were tilted toward the east as is usual for that phase. Suddenly, the upper horn split in two. From the midpoint of the division, a flaming torch sprang up, spewing out fire, hot coals, and sparks.

According to meteoriticist Jack Hartung, the small, bright-rayed crater Giordano Bruno lies in the region of the moon (which is just over the moon's northeastern limb) referred to by the Canterbury monks. Was this crater formed only 800 years ago? It's possible, but the odds are strongly against it. — *William Sheehan, author of* Changes of the Moon *(which will be published next year by the University of Arizona Press)*

CONTACT INFO

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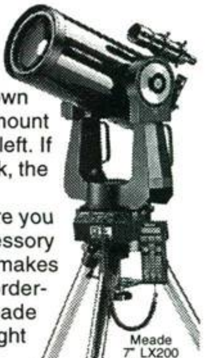
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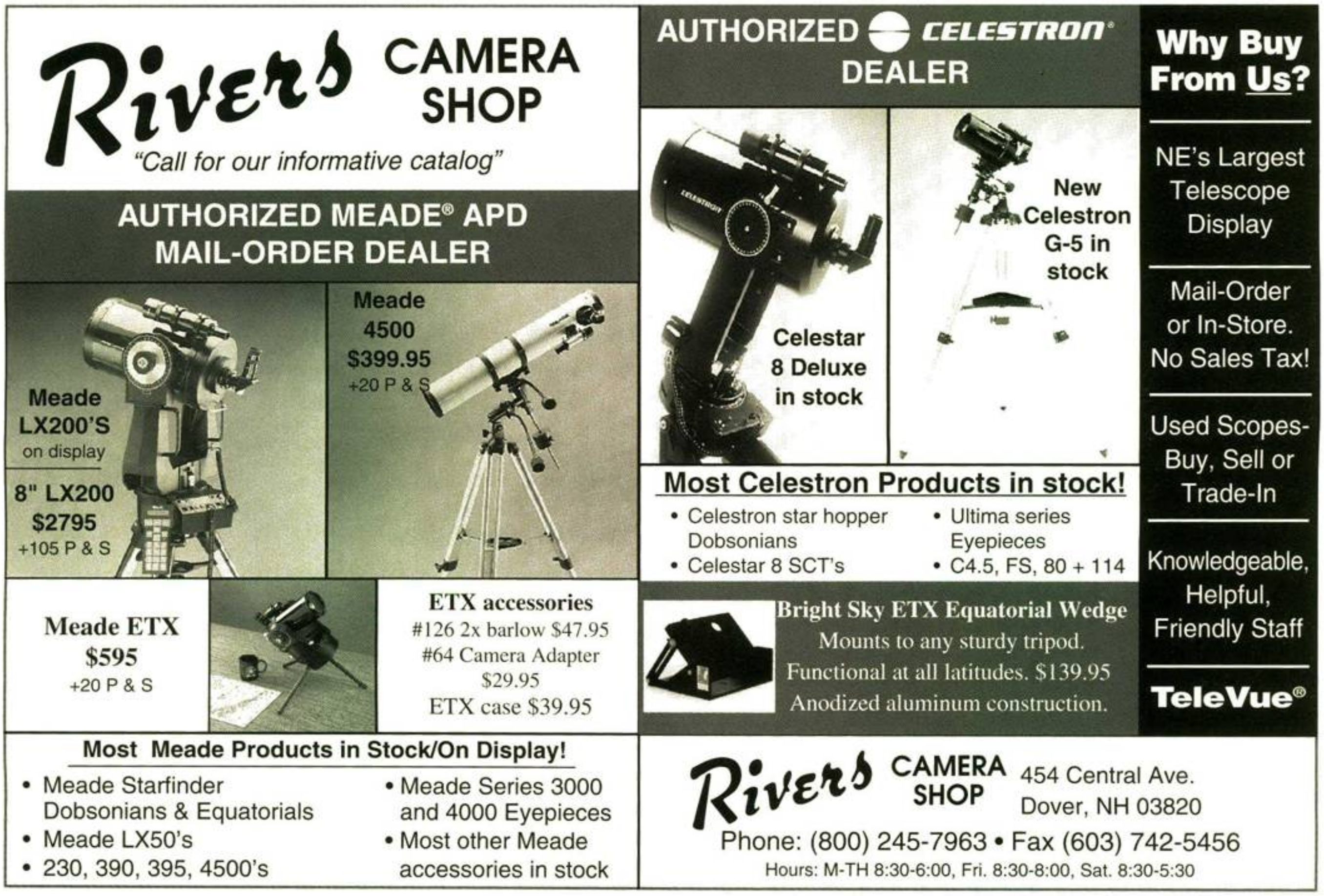
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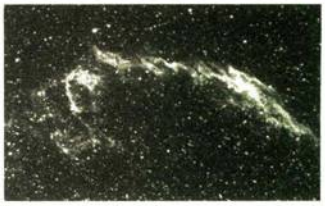

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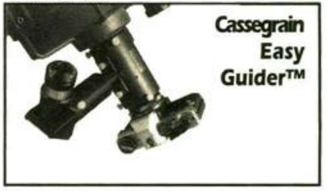
*US Pat. 4,448,500



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▶ Big budget movies and scientific missions have made asteroids a hot topic. To dispel myths, the Jet Propulsion Laboratory and Design Cast Studios have teamed up to offer $1/10{,}000$ scale models of the asteroids Toutatis and Castalia. Each three-dimensional reproduction is cast from computer models generated by using radar images of the asteroids.

The company offers basic and deluxe models (5" and 7" tall, respectively) and each includes a booklet that outlines the methods used to determine the asteroid's surface features. Written by Steven Ostro of JPL, the booklet also includes information on naming asteroids, past impacts with Earth, the likelihood of future impacts, and more.

The reproductions are being offered as a collectible series with the intent of releasing two new models each year: Geographos and Bacchus are next in line.

Design Cast Studios, 1245 Center Street, Henderson, KY 42420; phone, (888) 830-6412; fax, (502) 869-8479; website, http://www.dcstudios.com. Basic Model: $29.95, Deluxe Model: $59.95.

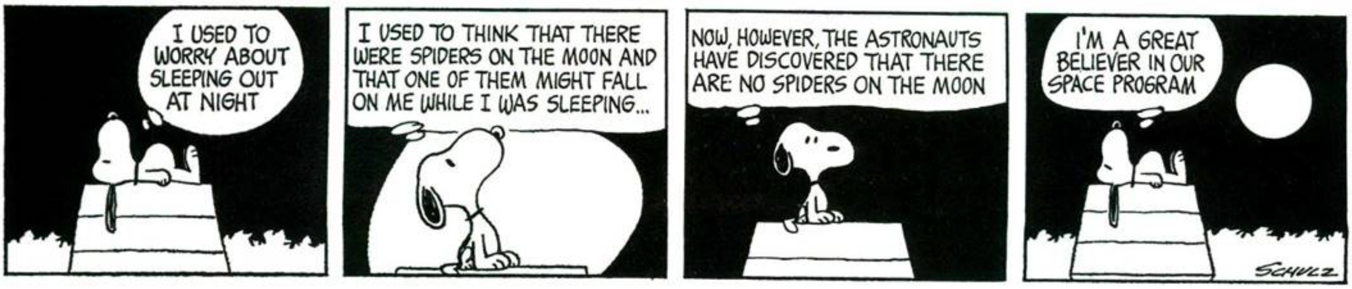
The Starsplitter Tube

▶ If you're looking for quality in a basic Newtonian-style telescope, Starsplitter Instruments may have the answer with its latest model, the Starsplitter Tube. This basic tube-style Newtonian joins the other portable and lightweight telescopes in the Starsplitter line.

The Starsplitter Tube rests on a high-quality Dobsonian mount, while the tube assembly itself has a cast aluminum mirror mount and a welded four-vane spider with a fully adjustable diagonal holder. The optical system is housed in a ¼" thick paper spiral tube with a plastic overcoat and end rings. A low profile 1¼" rack and pinion focuser is standard, but 2" focusers are also available.

The mount is constructed of Appleply plywood with virgin Teflon bearings and Ebony Star running surfaces. The tube assembly rotates on four nylon rollers that provide convenient eyepiece positioning for all viewing angles. The optics are offered in both high quality plate glass and Pyrex. The mirrors range in size from a 6-inch f/8, 8-inch f/6, and 10-inch f/5.6.

Starsplitter Telescopes, 3228 Rikkard Drive, Thousand Oaks, CA 91362; phone and fax, (805) 492-0489; website, http://www.starsplitter.com. Starsplitter Tube: $499 to $949.


I USED TO WORRY ABOUT SLEEPING OUT AT NIGHT
I USED TO THINK THAT THERE WERE SPIDERS ON THE MOON AND THAT ONE OF THEM MIGHT FALL ON ME WHILE I WAS SLEEPING...
NOW, HOWEVER, THE ASTRONAUTS HAVE DISCOVERED THAT THERE ARE NO SPIDERS ON THE MOON
I'M A GREAT BELIEVER IN OUR SPACE PROGRAM
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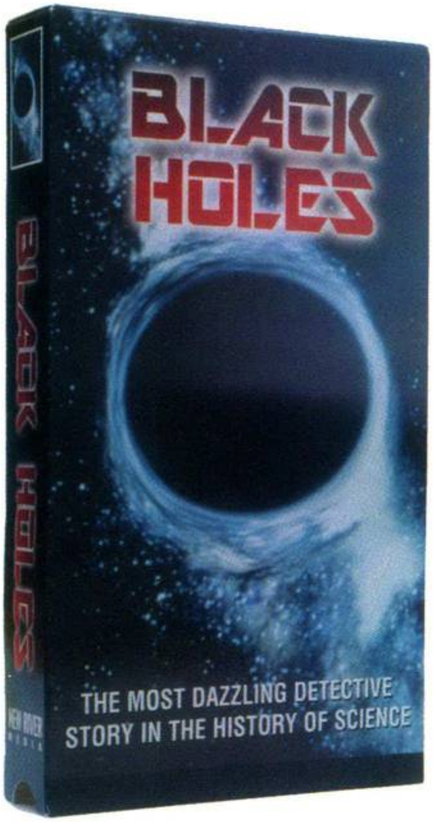
Black Holes

▶ What do Stephen Hawking and Bart Simpson have in common? The answer is *Black Holes*, a recent release from ARK Media Group. The 52-minute video presents the latest black hole research in an easily accessible manner. Scientists, including Sir Martin Rees, Kip Thorne, and Stephen Hawking, debate the current theories with the help of computer graphics and an animation segment from *The Simpsons*. Viewers not only learn about these powerful and violent objects, but they can see Homer Simpson "spaghettify" in a black hole as Bart watches the universe collapse in on itself. Other segments include event horizons, space-time warp, rotating black holes, worm holes, and black hole singularities.

ARK Media Group, P. O. Box 410685, San Francisco, CA 94141; phone, (415) 863-7200; fax, (415) 864-5437. *Black Holes:* $19.95



BOOKS

Looking for Earths: The Race to Find New Solar Systems

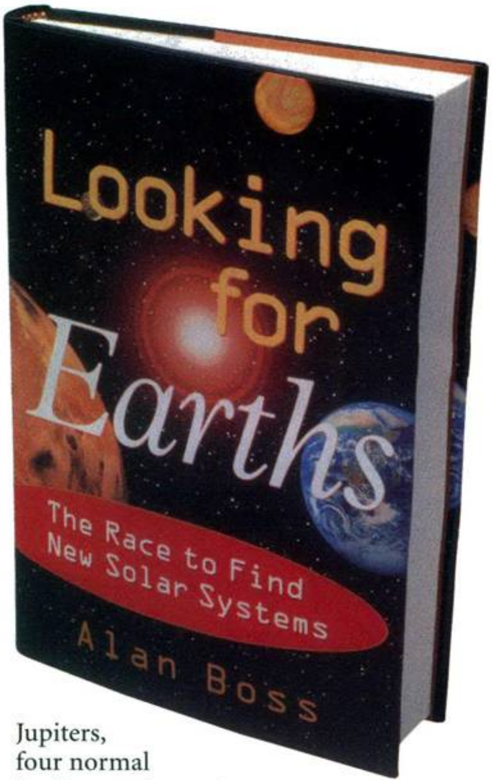
Alan Boss, 256 pages, John Wiley & Sons, New York, 1998; ISBN 0471184217; softcover, $27.95.

▶ "Are there planets elsewhere in the universe where creatures similar to *Homo sapiens* live and dream? Or are we alone in the unfathomable vastness of the universe? We are about to learn the answer to this anthropocentric illusion-shattering question."

So asserts theoretical planetologist Alan P. Boss in his prologue to *Looking for Earths: The Race to Find New Solar Systems*. As a leading theoretician at the Carnegie Institution in Washington, D.C. and an advisor to NASA, Boss possesses a unique insider's perspective that allows him to portray the reality of modern planet hunting. With the sympathy of a humble narrator, Boss takes readers on a thrilling journey of discovery. He details the actions of scientists who have created a new way of thinking about our solar system. And he shows how these remarkable finds have transformed this scientific field.

Boss sets the context with concise summary insights provided by some of the greatest astronomers of the past, including Ptolemy and his medieval epicycle theory and William Herschel and his discovery of Saturn. The meat of the story, however, begins in 1963 with Peter van de Kamp's discovery of a gas giant planet orbiting around Barnard's Star. Although van de Kamp's find was disproved ten years later, his work initiated the race to find extrasolar planets. It was, according to Boss, "a step as significant as Neil Armstrong's first step onto the Moon."

With the race for discovery, new technology came to light. Boss documents both the spectroscopic and astrometric methods of planet searching. He details the ingenious use of radio interferometry and describes the politics surrounding the building of large telescopes as well as whole scientific communities. The dramatic and suspenseful journey ends in 1997 with "an incredibly rich crop of gas giant planets and brown dwarf stars: four hot Jupiters, four normal Jupiters, and seventeen brown dwarf stars."



Along the way, it is clear that Boss views all his fellow scientists with the compassionate eye of a compatriot. With his courtside seat, he is well equipped to share how meetings and conferences work, how research monies — and opportunities — are distributed, and how information gets presented to the press.

He concedes that scientists sometimes compete vigorously for the same money and prestige, invoking intense competition. "Being a very critical bunch by training, if not by nature," Boss says, "scientists usually do not mind finding errors in the work of others, and some even seem to take delight in this task."

He doesn't seem to delight in this task, however. When ideas are disproved, it is with sadness and compassion that Boss describes the failure. His book is full of humor, heartbreak, and a deep understanding of the ardor and luck that compose years of research.

The book is also full of complex theories made easy to understand. Boss often clarifies observations with precise, down-to-earth metaphors. Van de Kamp's theory about mass centers for stars and their planets, for example, is compared to children on a teeter-totter, while Chamberlin and Moulton's tidal

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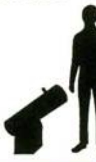

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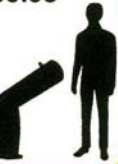

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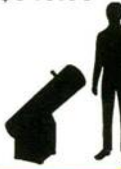

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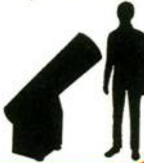

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hypothesis is likened to a weed whacker. It's apparent that although Boss is involved in serious work, he doesn't take himself too seriously. Lucille Ball, Harpo Marx, Crocodile Dundee, and even the 1996 movie *Independence Day* make appearances in the book.

In addition, Boss's language is pleasurable. Planets are described as "unseeable wraiths that eluded capture," while protostars are "awkwardly trying to find a stable arrangement, like a newlywed couple with sudden misgivings." Later, the orbits of binary stars are "like a long married couple who have found that the best way to maintain a stable relationship is to keep a certain distance from each other."

Looking for Earths also contains a helpful list of acronyms — an especially useful resource, because acronyms play a large role in the thread of the plot. Boss explains, "The only thing worse for a NASA program than having no budget is having no acronym." And perhaps the only thing worse than that is a bad acronym. Boss points out that pronounced aloud, TOPSSWG (Toward Other Planetary Systems Science Working Group) is more amenable than PSSWG (Planetary Systems Science Working Group).

As Boss looks upward and outward, he never loses sight of where he stands, grounded in humanity. As a result, the reader becomes not merely a receiver of Boss's vision, but a fellow explorer. Eventually, the journey we begin with him ends with the possibility of a distant future where interstellar aliens exist. Boss seems to emphasize the word "looking" in the book's title and to implicate us all in the quest for a greater understanding of our universe.
— *Mira Dougherty-Johnson* A

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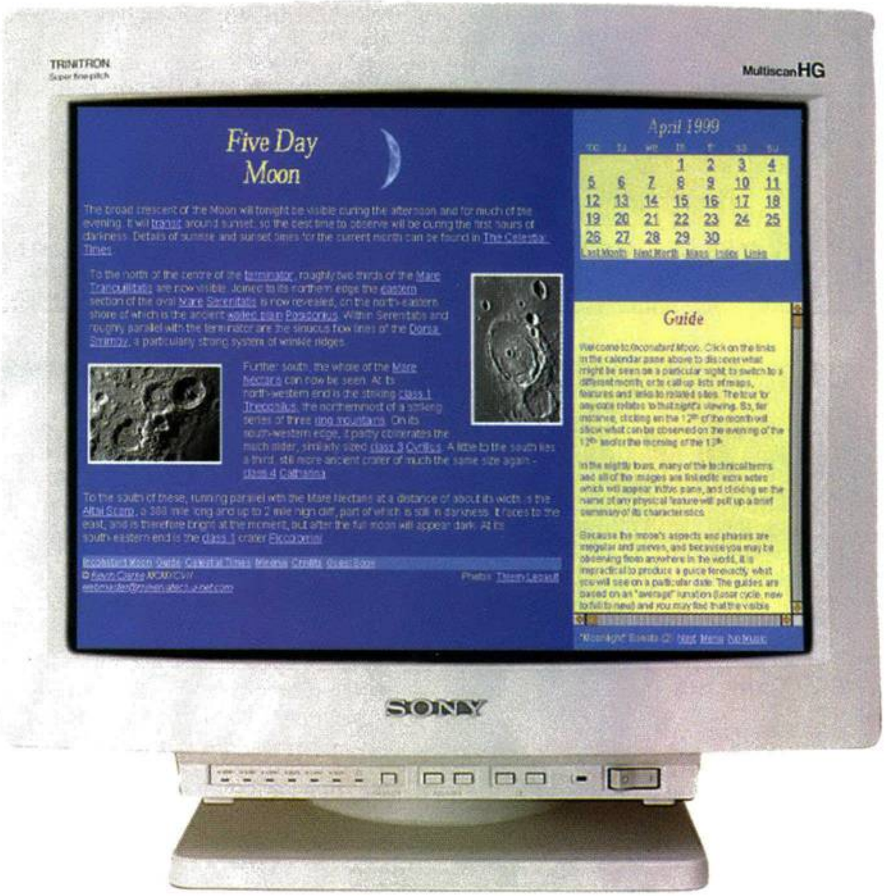

The Webweaver Picks

The Moon is the most easily observable astronomical object in the sky — even a modest pair of binoculars can reveal its features. The following sites provide you with phase information, lunar history, and more. So find a "marvelous night for a moon dance," and bring out a bit of the selenologist in you.

The Inconstant Moon (pictured)
http://www.minervatech.u-net.com/moon/index.htm
The site features an interactive calendar that produces an image of the moon's phase for each day of the year. It also provides photos and information on the best lunar features to see on the selected day. Should you so desire, a moon-related tune can serenade your exploration of the site.

History of the Moon
http://lunar.arc.nasa.gov/history/moonh.html
It also features links to a timeline and lunar mythology pages.

Lunar Exploration
http://nssdc.gsfc.nasa.gov/planetary/lunar/
Learn more about NASA's missions to the moon from the Ranger and Surveyor in the 1960s to the Lunar Prospector mission of 1997.

The Moon
http://seds.lpl.arizona.edu/billa/tnp/luna.html
A comprehensive site with many links that provide more in-depth information.

Earth and Moon Viewer
http://www.fourmilab.ch/earthview/vplanet.html
View the Earth from the sun and moon, and see the moon from either the sun or Earth. You pick the day, time, longitude, latitude, altitude, and more. The site also features links to Earth- and moon-related screen savers.

Virtual Reality Moon Phase Pictures
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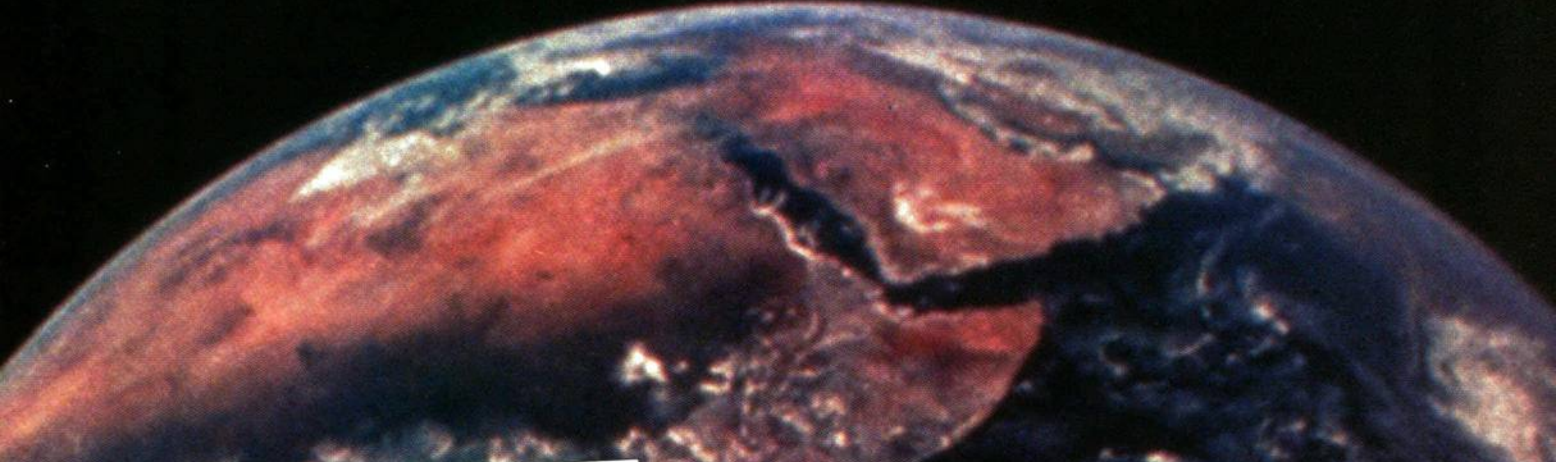

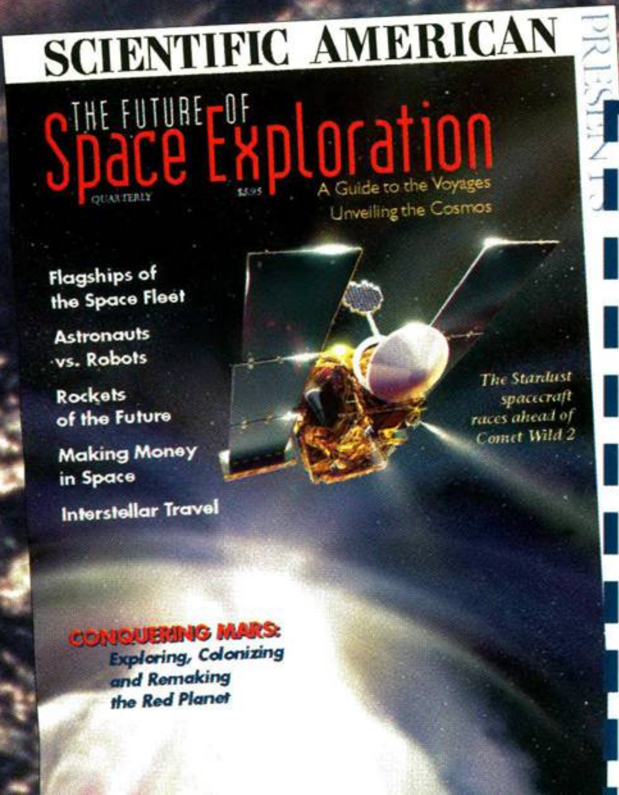
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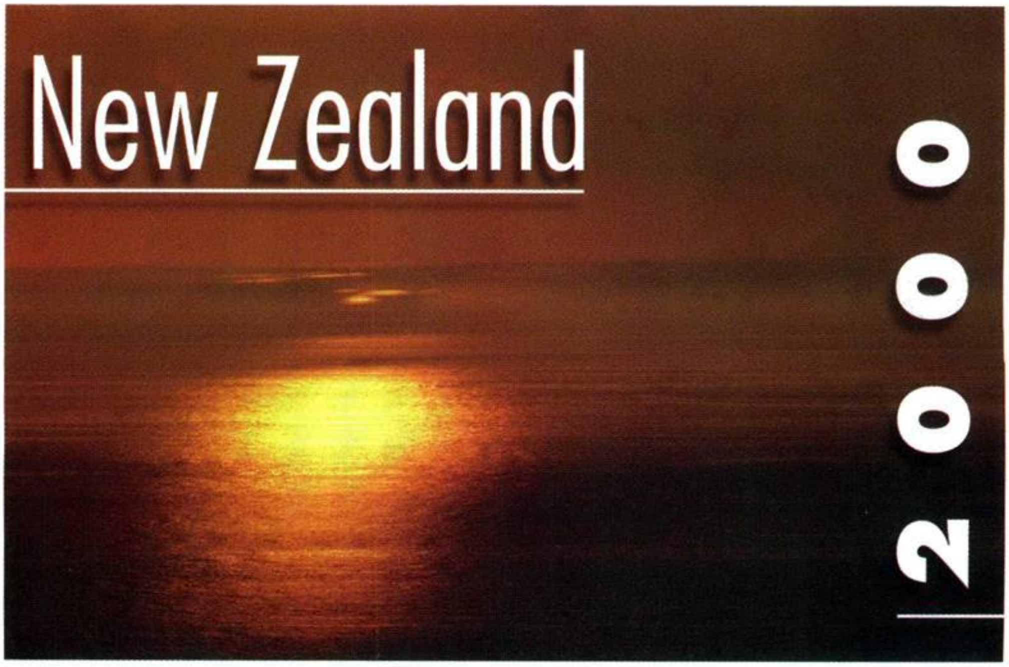

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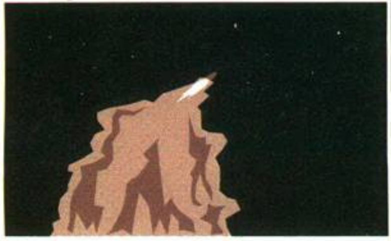

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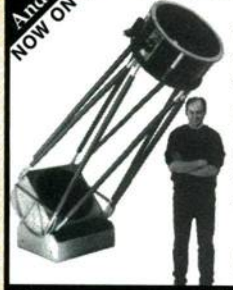

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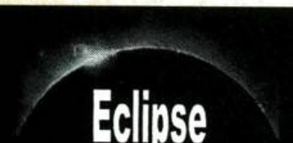

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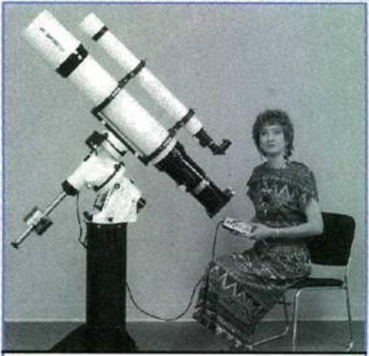

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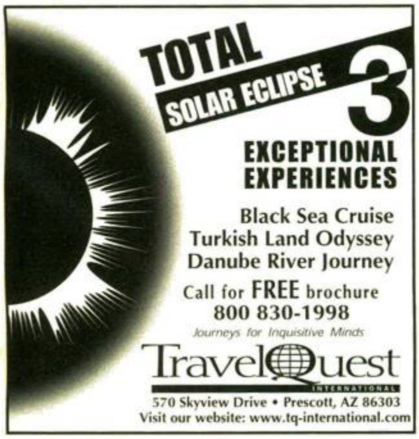

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The **Peach State Star Gaze VI** will be taking place **April 15–18** at Indian Springs State Park's Camp McIntosh near Jackson, Georgia, southeast of Atlanta. Activities taking place, day and night, include observing competitions, workshops, and presentations by featured speaker Phil Harrington and others. For more information contact Ken Poshedly, 1741 Bruckner Court, Snellville, GA 30078-2784; (770) 979-9842; e-mail, ken.poshedly@mindspring.com.

Two hundred to three hundred visitors are expected to attend the spring **Central Texas Star Party, April 16–17**, at Pedernales Falls State Park, just east of Johnson City, Texas. No registration will be required and the only fees charged are those required to enter the park or to camp overnight. Contact the Austin Astronomical Society, P. O. Box 12831, Austin, TX 78711 or telephone David Sands, (512) 252-2966. Further information may be found at the AAS website, http://www.main.org/aas. For camping arrangements, call State Park Reservations, (800) 389-8900.

The Tuckahoe State Park in Queen Anne, Maryland, will be home to the **Fifth Annual Delmarva Star Gaze, April 16–18**. The park, on the Delmarva Peninsula, has exceptionally dark skies. The observing site has no visible white lights. While the highlight will be dark sky observing, there will also be swap tables, talks and slide presentations, door prizes, and a Newtonian telescope will be constructed from mirror grinding through to completion. For additional information, contact Lyle Jones at (302) 736-9842 or see the Delmarva Stargazers' website, http://www.delmarvastargazers.org.

John Chumack

The Milky Way over Mount Lemmon Observatory. Photographed during the Advanced Astronomy Camp sponsored by the University of Arizona.

APRIL 14–17
Mid-South Star Gaze

▶ Rainwater Observatory, French Camp, Mississippi. Contact James Hill, (601) 547-6865; website, http://rainwater.astronomers.org.

APRIL 15–18
Peach State Star Gaze

▶ Indian Springs State Park, Camp McIntosh, near Jackson, Georgia. Contact Ken Poshedly, 1741 Bruckner Court, Snellville, GA 30078-2784; (770) 979-9842; e-mail, ken.poshedly@mindspring.com.

APRIL 16–17
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▶ Pedernales Falls State Park, Johnson City, Texas. Contact the Austin Astronomical Society, P. O. Box 12831, Austin, TX 78711; David Sands, (512) 252-2966.

APRIL 16–18
Delmarva Star Gaze

▶Tuckahoe State Park, Queen Anne, Maryland. Sponsored by the Delmarva Stargazers. Contact Lyle Jones, (302) 736-9842; e-mail, lyjones@state.de.us.

APRIL 16–19
Adult Beginning and Advanced Astronomy Camp

▶ Mount Lemmon and Mount Bigelow Observatories, University of Arizona, Tucson, Arizona. Contact Don McCarthy, 933 North Cherry Avenue, Tucson, AZ 85721; (520) 621-4079, e-mail, dmccarthy@as.arizona.edu; website, http://ethel.as.arizona.edu/astro_camp.

APRIL 23–24
NIAGfest Astronomy Convention

▶ Camp Crosley, North Webster, Indiana. Contact Mike Beaver, (219) 594-2355 (eves.); e-mail, michael.beaver@kconline.com; website, http://clubs.kconline.com/was/niag.htm.

APRIL 30–MAY 1
North Central Regional Astronomical League Convention

▶ Sheraton Four Points Hotel, Cedar Rapids, Iowa. Hosted by the Cedar Amateur Astronomers. Contact Deb Bonser, 1009 Harding, Tama, IA 52339; (515) 484-5235; e-mail, deb.bonser@usa.net.

MAY 9–16
Texas Star Party

▶ Prude Ranch, Fort Davis, Texas. Contact the TSP Registrar, 1326 Mistywood Lane, Allen, TX 75002; e-mail, kastro@aol.com; website, http://www.metronet.com/~tsp/index1.html.

CONTACT

Please submit club announcements four months in advance to Looking Ahead, *Astronomy*, P.O. Box 1612, Waukesha, WI 53187, or to tconley@astronomy.com. Look for additional events at http://www.astronomy.com.

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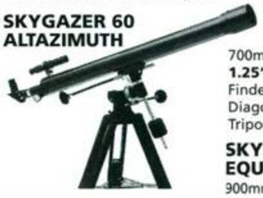

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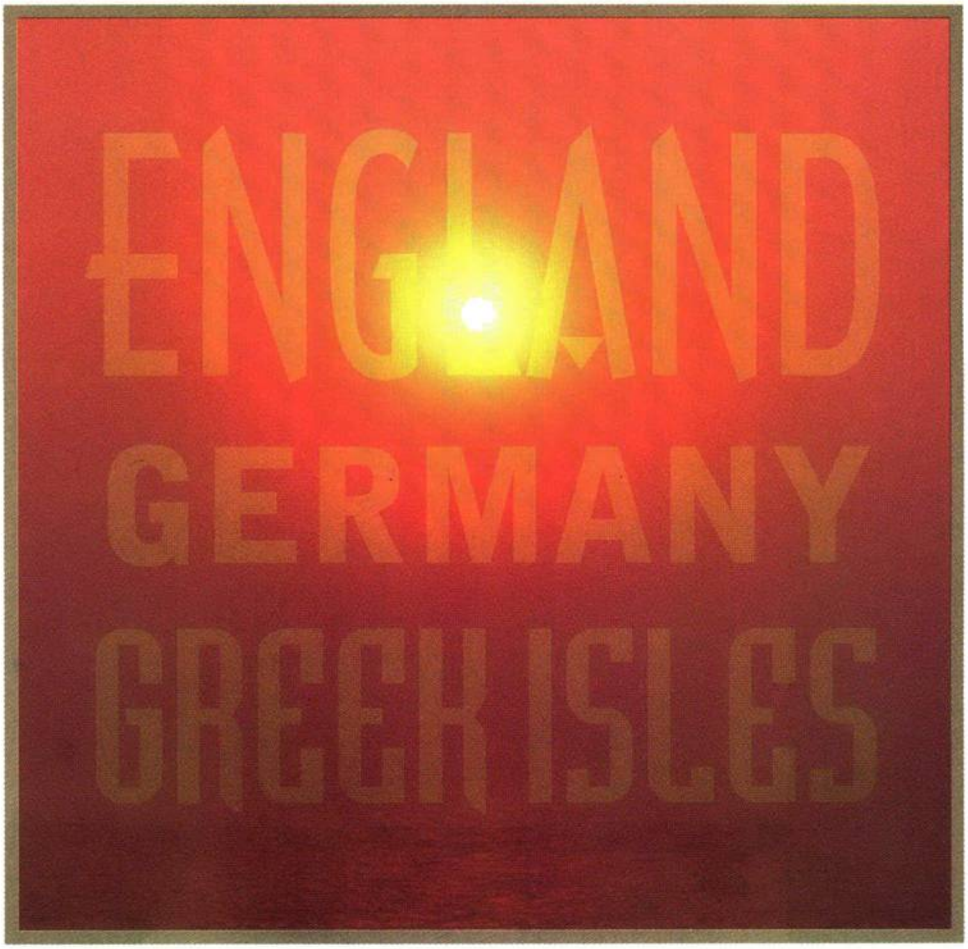
Astronomy Magazine presents

1999 solar eclipse tours



Come join *Astronomy* Magazine on one of its four amazing solar eclipse tours being held August 6-15, 1999. Along with catching one of the most spectacular views of the last solar eclipse of the 20th century, you will experience the magnificent sights and sounds of such wonderful places as England, Germany, and the Greek Isles in the process. Choose your favorite destination today.

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HOT SHOTS

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GALAXY HUNTING

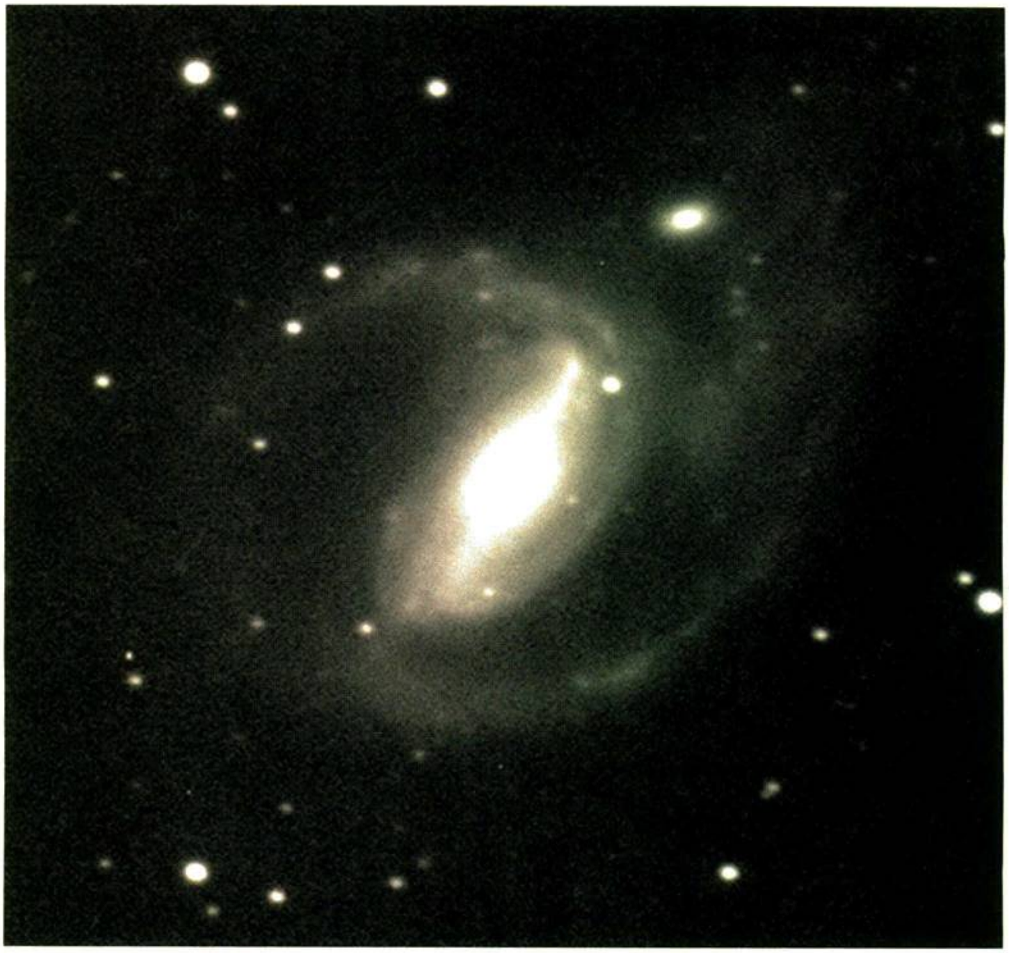
Shooting Spirals from the Hip

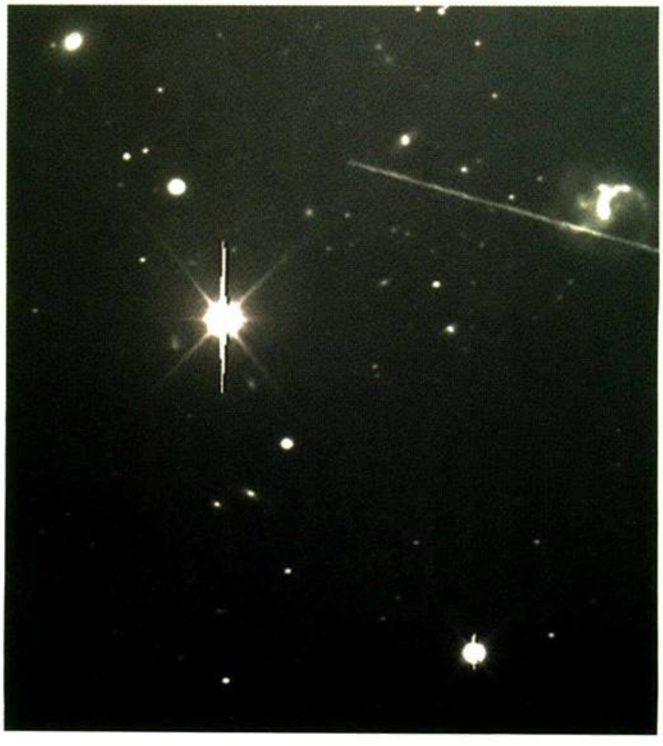
▶ What's the best thing to do for deep-sky CCD fans on the evening of the Leonid meteor shower, potentially the most active one in decades? Why, go out and image galaxies, of course. That's why friend James McGaha and I decided to try to image 100 Arp galaxies in a single night. (We did peek at a couple of meteors, too.)

For the past year or so, the Astronomical League, a federation of astronomical societies, has sponsored an Arp Galaxy Club. The requirement for membership is to image or observe 100 Arp galaxies. This drove us to the task.

Arp galaxies are not any old galaxies, either. Named for the American astronomer Halton C. Arp who catalogued them, Arp galaxies are the real oddballs in a universe filled with oddities. They are the so-called peculiar galaxies: galaxies contorted by collisions with each other or twisted by tidal interactions inside clusters; or hyperenergetic galaxies undergoing internal upheavals powered by starbursts, active black holes, or chains of supernovae. Because of their odd forms, they're fun to look at. Some incredible details in Arp galaxies are visible in backyard telescopes.

Some 338 galaxies belong to Arp's catalog, and for the club certificate,





Spiral Galaxy NGC 1097 (Arp 77) in Fornax

TIM HUNTER AND JAMES MCGAHA

(24-inch f/5 reflector, Apogee AP 7 CCD camera)

Spiral Galaxy NGC 145 (Arp 19) in Cetus

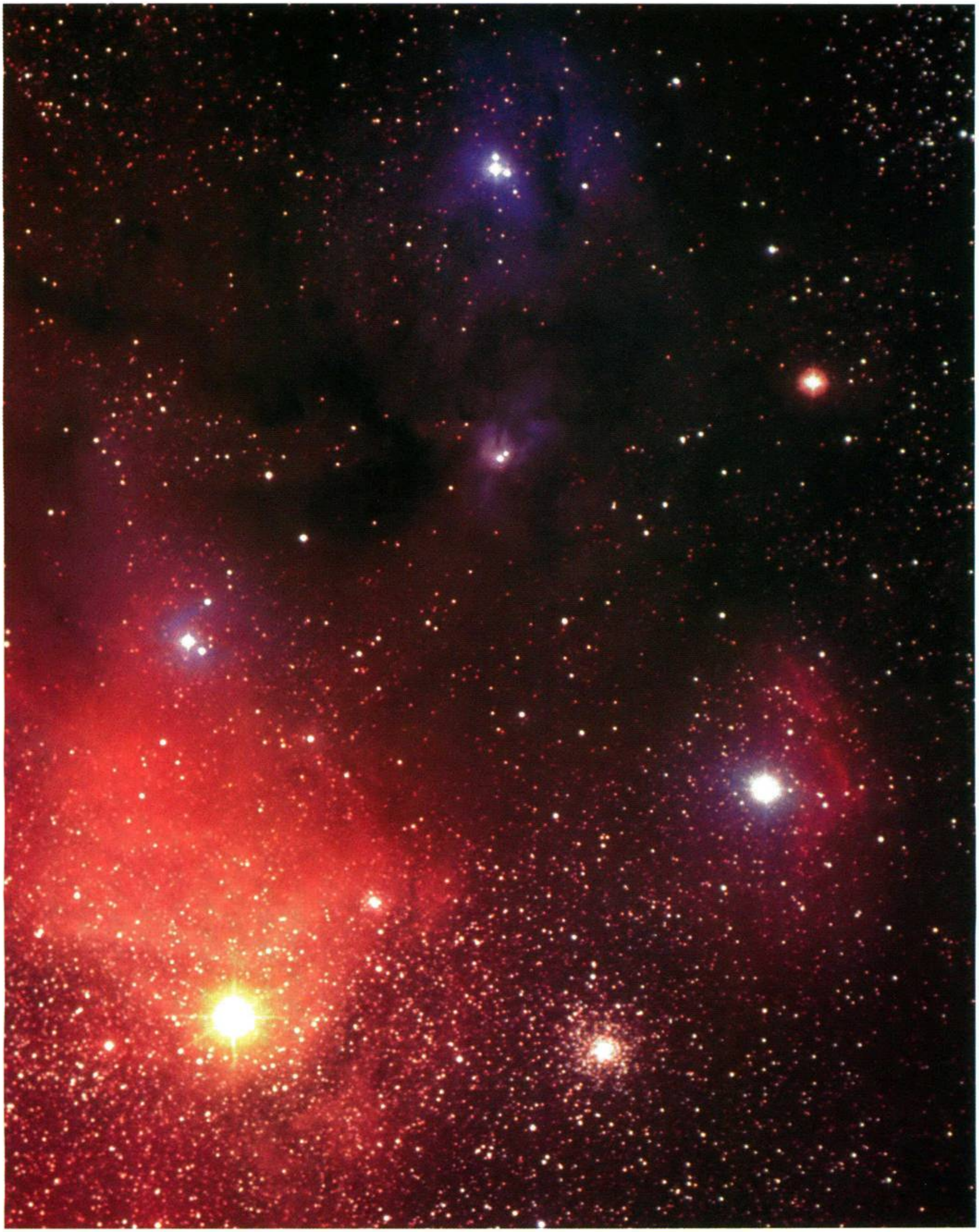
TIM HUNTER AND JAMES MCGAHA

(24-inch f/5 reflector, Apogee AP 7 CCD camera)

Rho Ophiuchi Region

BILL AND SALLY FLETCHER

(8-inch f/1.5 Schmidt camera, Tech Pan film, tricolor composite using 16-minute red, 58-minute green, and 65-minute blue exposures)



observers or imagers can choose their own 100 to target. For our effort, we selected the 24-inch f/5 reflector at Grasslands Observatory in southeastern Arizona. We used an Apogee AP 7 CCD camera for the imaging and took exposures of one minute each through a clear filter.

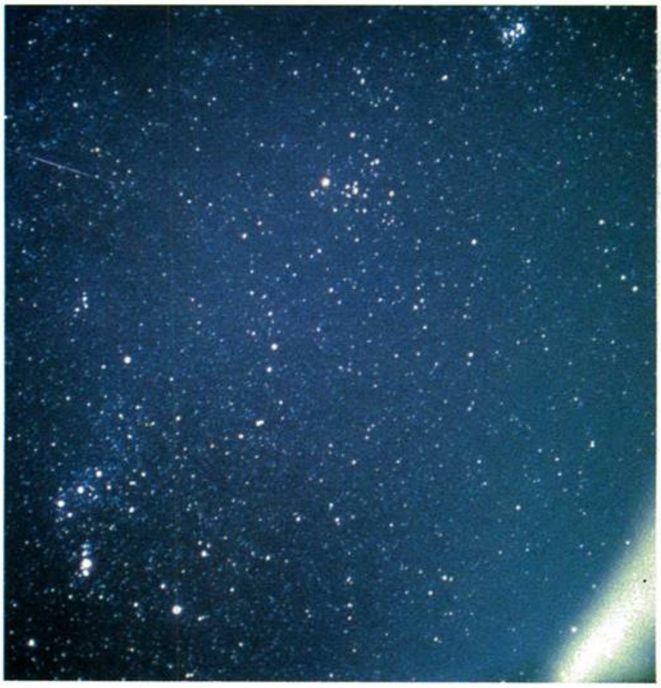
As the night began, Jim controlled the computer and I moved the telescope from object to object. We compared our CCD images to the relevant charts from the MegaStar sky chart software to make certain we were imaging the correct galaxy. We found the various lists of Arp galaxies prepared by amateur astronomer Dennis Webb (members.aol.com/arpgalaxy/) to be especially helpful.

As we targeted each galaxy, we imaged it as close to the meridian as possible. We went on relentlessly, through Pegasus, Pisces, Cetus, Fornax, Eridanus, Lepus, Orion, Leo Minor, and Lynx. This took us from 8:15 P.M. until 3 A.M., and when we finished, we had imaged a total of 101 Arp galaxies.

Then we shut down the telescope, our minds somewhat fogged from the sheer number of galaxies we had visited, and relaxed on lawn chairs to watch the Leonids. It was spectacular. There were bursts of meteors producing brief intervals with the equivalent hourly rate of 1,000 meteors an hour.

It was the best shower either of us had ever seen. Such a show above coupled with probes of distant, warped galaxies made a great combination.

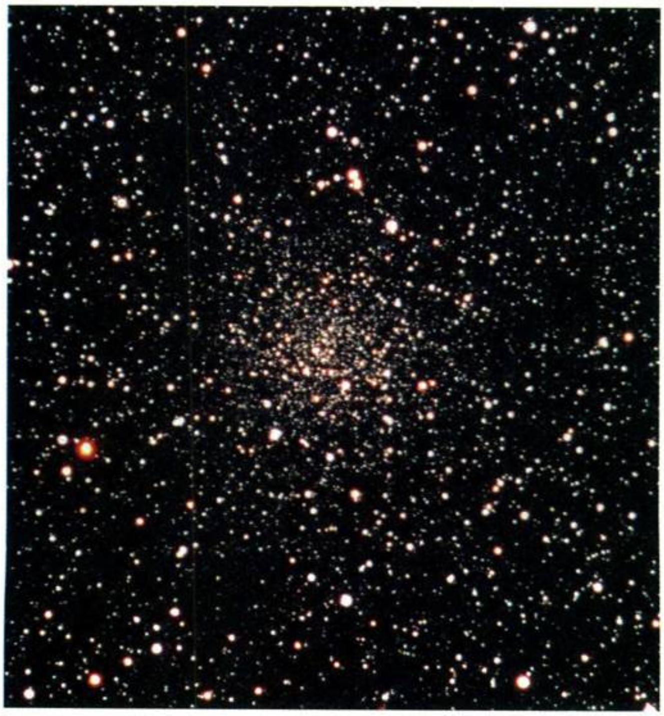
Tim Hunter is an astronomer living in Tucson.



Leonid Meteors Zip Past the Hyades and Orion

ALBERTO LEVY

(16mm lens at f/2.8, Ektachrome 1600 film, 15-minute exposure taken November 16/17, 1998)



Open Star Cluster NGC 6791 in Lyra

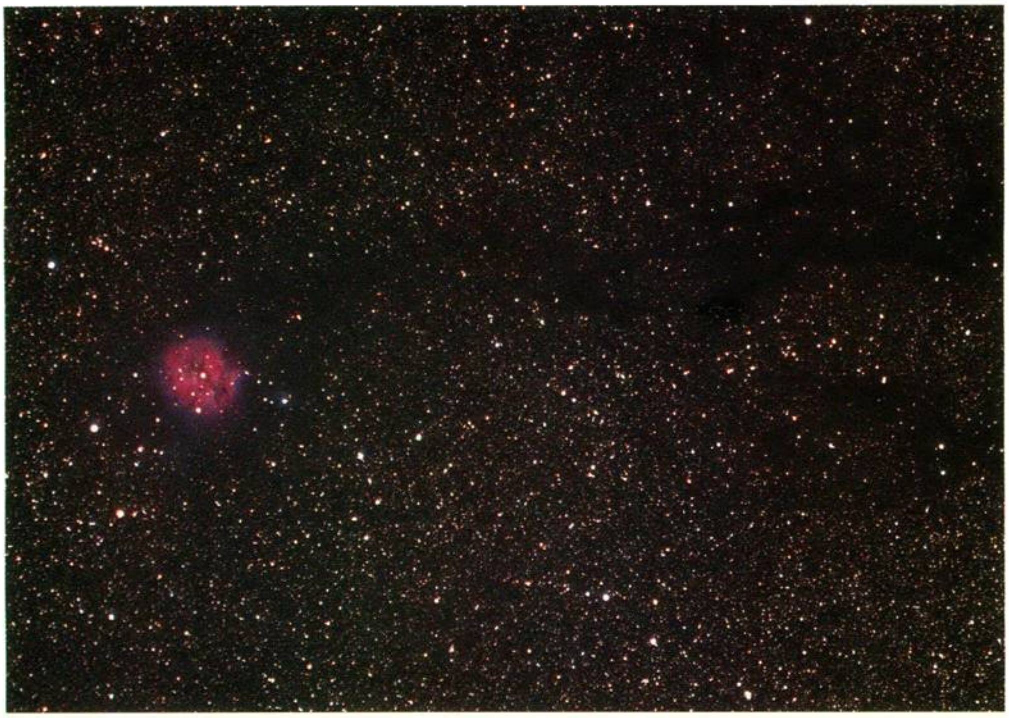
MICHAEL STECKER

(6-inch f/7 refractor, hypersensitized Kodak Pro 400 film, 35-minute exposure)

The Andromeda Galaxy

CHRIS COOK

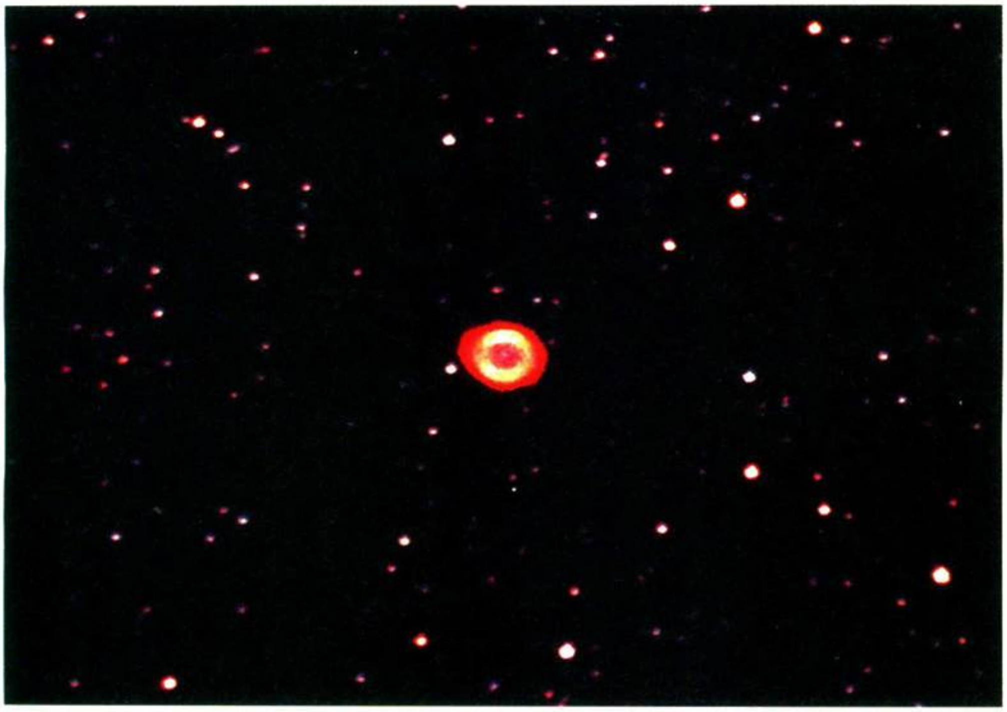
(3.3-inch f/7.8 refractor, hypersensitized Kodak Pro 400 film, composite of three 55-minute exposures)



The Cocoon Nebula (IC 5146) in Cygnus

GEORGE GREANEY

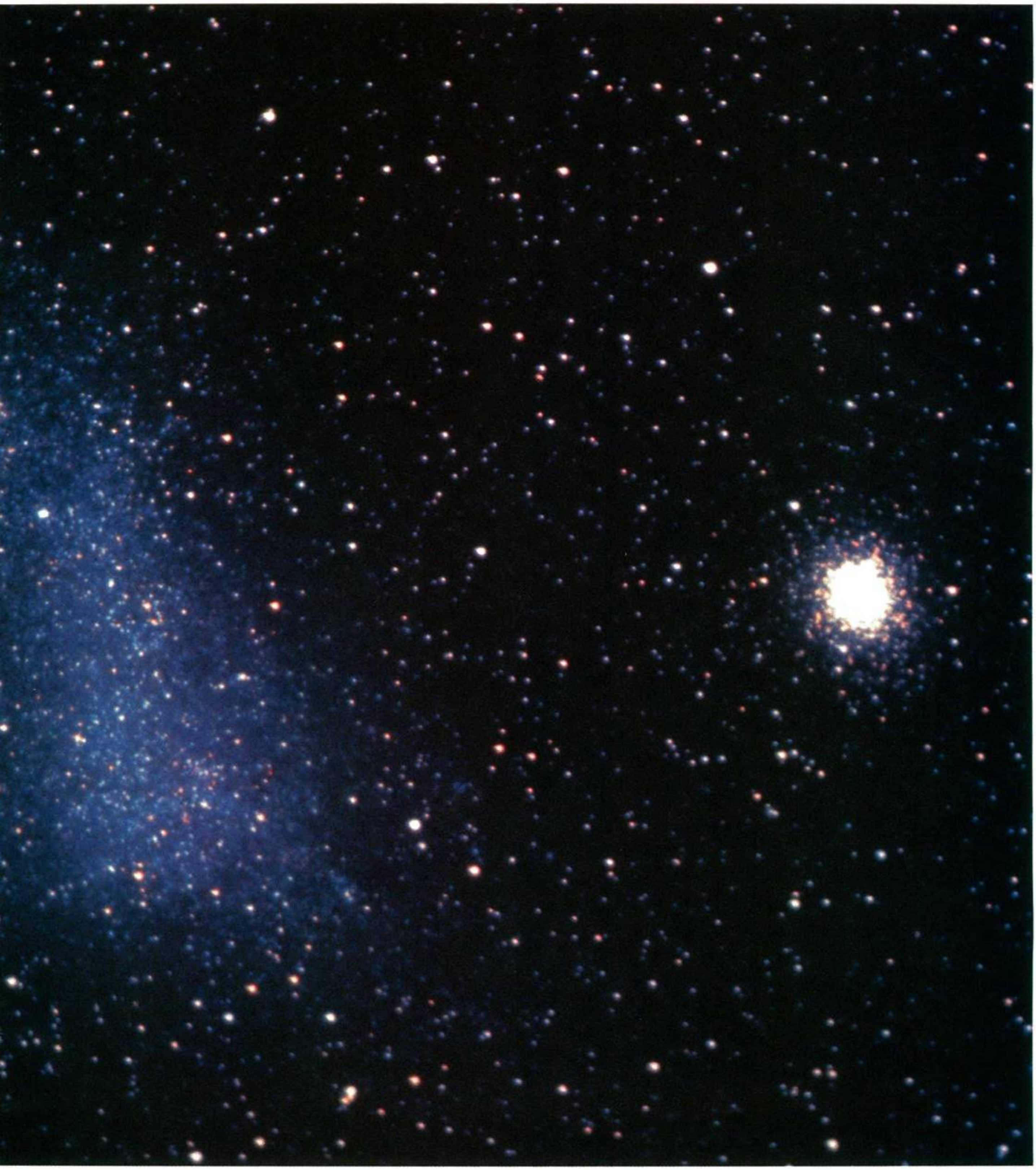
(6-inch f/7 refractor, composite of two 60-minute exposures)



The Ring Nebula (M57) in Lyra

KENNETH BLUMBERG

(8-inch f/10 SCT, Kodak Royal Gold 400 film, 30-minute exposure)

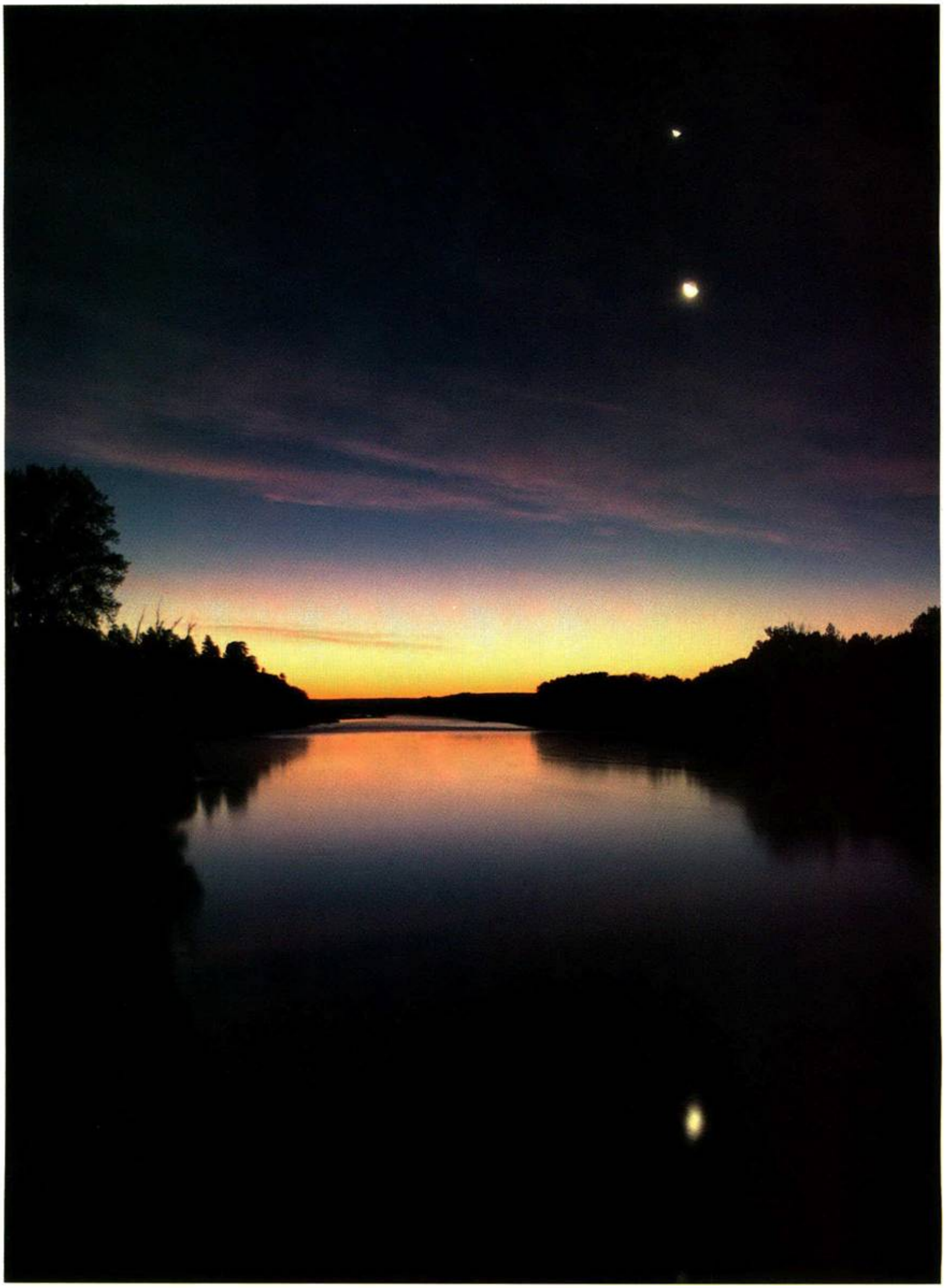


The Small Magellanic Cloud and 47 Tucanae

FRED ESPENAK

(300mm lens at f/4, Fuji Super G 800 film, 25-minute exposure)

This month's best astrophoto



Mercury and Venus Join a Crescent Moon

JOHN MCNEAL

(28mm lens at f/2.8, Fuji 100 film, 20-second exposure taken October 9, 1996)

The Yellowstone River provides a peaceful setting for contemplating planets in the early morning sky over Pompeys Pillar, Montana.

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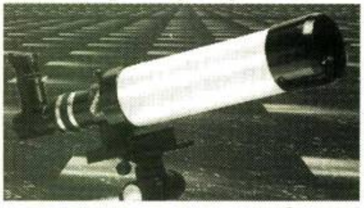

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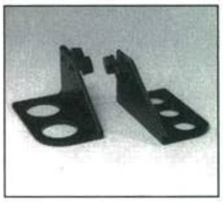

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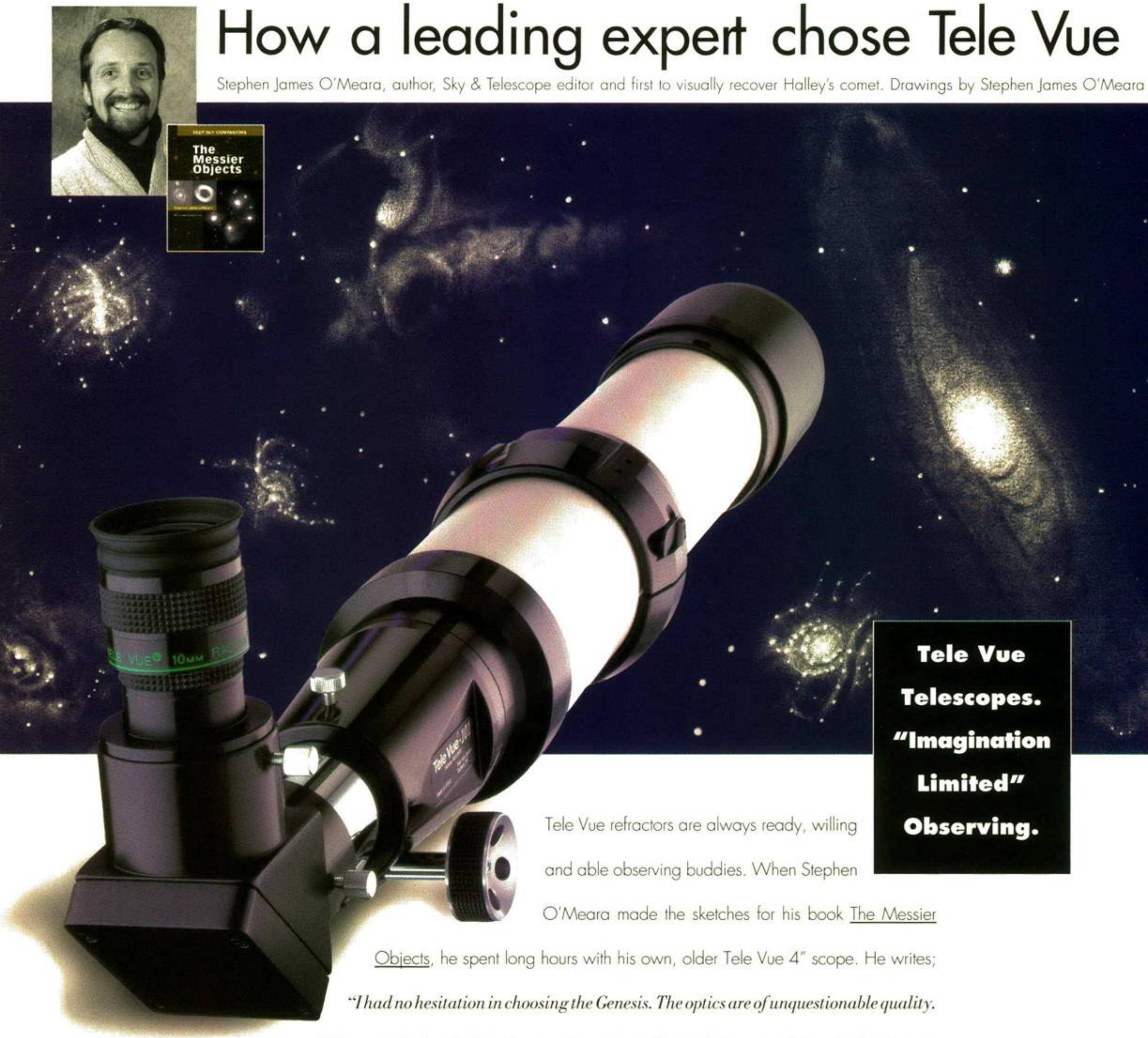

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The Lagoon Nebula (M8) in Sagittarius. Photographed with a Meade 10" f/10 LX200 Schmidt-Cassegrain Telescope in southern France by Philip Perkins of Wiltshire, England. Mr. Perkins used two exposures of 80-mins. and 85-mins. on hypered Kodak Ektapress Multispeed PJM-2 film; the negatives were scanned and then digitally stacked to form the final image.

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